United States Department of Agriculture

Economic Research Service

Forest Service

Soil Conservation Service

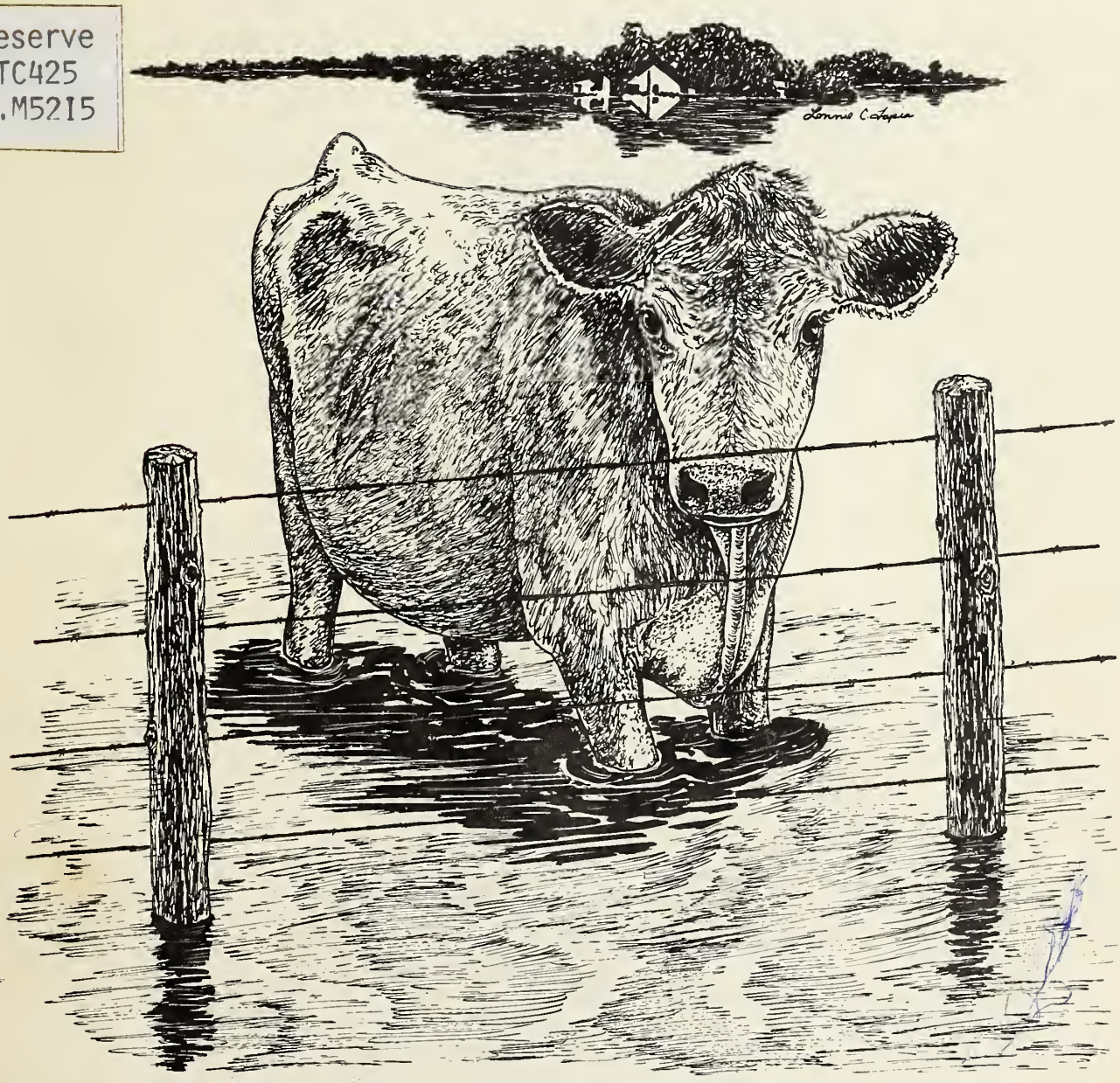
in cooperation with

State of Missouri

State of Iowa

The Land and Water Resources of the Northern Missouri River Tributaries Basin — Iowa and Missouri

An Inventory and Analysis Summary Report
April, 1982



INVENTORY AND ANALYSIS

SUMMARY

REPORT

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

IOWA AND MISSOURI

Prepared by:

State of Missouri
State of Iowa
U.S. Forest Service
U.S. Economic Research Service
U.S. Soil Conservation Service

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U.S. DEPARTMENT OF AGRICULTURE

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

IOWA AND MISSOURI

PREFACE

The natural resources of the Northern Missouri River Tributaries Basin of Iowa and Missouri provide a variety of goods and services to the region and the Nation. The 18,539 square miles of land and water are used in producing food, fiber, minerals, energy, recreation, wildlife, and other amenities. The depletion of the natural resource base, over time, and the conflicts among uses are major concerns of this study.

This study was conducted in accordance with the Principles and Standards for Planning Water and Related Land Resources issued by the Water Resources Council, the President's Water Quality Directives and the USDA Procedures for Planning Water and Related Land Resources, under Section 6 of PL 83-566. The purpose of water and land resource planning is to promote quality of life by reflecting society's preference for attainment of:

(1) National economic development enhancement by increasing the value of the Nation's output of goods and services and improving national economic efficiency.
(2) Environmental quality enhancement through the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

The study has been divided into two phases. The first, the inventory phase, identifies resource uses and problems identified with these uses. Chapters 1 and 2 of this report cover the first phase. The decision was made to limit the second phase to studying solutions of erosion and flooding problems in the Lower Grand River subbasin. The results of the Lower Grand River study will be presented in later reports. The second, the program phase, will be restricted due to time and money limitations. Chapter 3 of this report offers recommendations applicable to the entire basin.

Data for this report were collected in two concurrent studies conducted in Iowa and Missouri. The general objectives of the two studies were similar in that hydrologic-sedimentation relationships were needed for both studies. Hyrologic relationships were, therefore, established for the total area and used for analysis in both Iowa and Missouri.

The scope and intensity of the specific objectives for the states were different. Consequently, the amount of basic data collected, methods of documentation, time schedules, and state and local participation varied between states.

The results of the Iowa study were documented in a cooperative USDA-Iowa report (Southern Iowa River Basin Report). The results of the inventory data collected for the State of Missouri were documented in 21 Inventory and Analysis Reports listed in Section F of this chapter. The Iowa report and data files and the Missouri Inventory and Analysis Reports provided the detailed information for this report.

Some inventory data were available for the entire basin. Other inventory data in this report were obtained and summarized for the Missouri part of the basin only.

A. Initiation

The State of Missouri and the State of Iowa requested the United States Department of Agriculture to conduct a USDA Cooperative River Basin Study of the Northern Missouri River Tributaries Basin. The sponsors are:

State of Missouri	State of Iowa
Department of Agriculture	Department of Soil Conservation
Office of Administration	Natural Resources Council
Department of Conservation	Southern Iowa Conservancy District
Department of Natural Resources	
University of Missouri-Columbia	

B. Authority

The study was made under the authority of Section 6 of the Watershed Protection and Flood Prevention Act of the 83rd Congress (Public Law 566, as amended). Under this Act, the Secretary of Agriculture has the authority to cooperate with other federal, state, and local agencies in their investigations of rivers, watersheds, and other waterways to develop coordinated plans and programs. The study was authorized by the Administrator of the Soil Conservation Service March 13, 1975.

C. Objectives

The principal objective of the study was to provide local, state, and federal decision makers with alternative plans for the orderly conservation, development, utilization, and management of the basin's water and land resources. This report sets the stage for plan development.

Specific objectives identified by the public and the states were developed separately by the State of Iowa and the State of Missouri.

Specific objectives listed by Iowa in the Southern Iowa River Basin Report were (1) alleviation of floodwater and sediment damage, (2) proper land treatment and management, and (3) water supply.

In Missouri, specific objectives were determined through meetings with the state sponsors, cooperating state agencies, and the public in public meetings. The State of Missouri provided input through the State Water Plan Task Force consisting of 15 representatives. In Missouri, 11 concerns were expressed in meetings with the public and with the Missouri coordinating committee members. These concerns are:

1. Analyze flood damages and provide for reduction using structural and nonstructural measures where economically and environmentally feasible.

2. Determine the extent of the problems and the potential for improvement by using land according to its capabilities. Abide by Section 303 and 208

Programs of Public Law 92-500, (Federal Water Pollution Control Act). The states are carrying out provisions of the Act.

3. Determine capacities of existing municipal water supply reservoirs to determine added capacity needed for present and future (year 2000) conditions. Determine sources of ground or surface water supply and coordinate water supply systems.

4. Determine the feasibility of supplemental irrigation, inventory land and water resources, and determine cost returns to evaluate feasibility.

5. Identify and list sources of pollution and determine the importance of each.

6. Use federal and state criteria to determine areas of prime and important agriculture land by counties in the basin.

7. Determine the resource conflict with water, agriculture, transportation, and others if coal is mined.

8. Update the wetland inventory and analyze trends. Determine the potential use of streams.

9. Determine the effects of high-water stages on agriculture.

10. Prepare a data base for continued planning and evaluation of recreation developments. Identify potential recreational development for public and private facilties.

11. Investigate and quantify the loss of wildlife habitat and analyze its effect on wildlife, to determine the potential for the expansion and/or diversity of wildlife habitat.

D. USDA And Sponsoring Participation

The Memorandum of Understanding, revised April 6, 1968, between the Soil Conservation Service, the Forest Service, and the Economic Research Service established the ground rules of USDA agency participation. The Soil Conservation Service provided leadership for the study.

The State of Iowa and the State of Missouri are the sponsors. Participating agencies are listed under Acknowledgements.

E. Acknowledgements

Local, state, and federal agencies with water development, water, and land resource program responsibilities provided data, assistance, guidance, and review. Contributions by other individuals and groups not listed are acknowledged in technical reports.

U.S. Agricultural Stabilization and Conservation Service
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency

U.S. Bureau of Census
Heritage, Conservation and Recreation Service
U.S. Fish and Wildlife Service
U.S. Geological Survey
Iowa Conservation Commission
Iowa Department of Environmental Quality
Iowa Department of Soil Conservation
Iowa Department of Transportation
Iowa Development Commission
Iowa Geological Survey
Iowa Natural Resources Council
Iowa Office for Planning and Programming
Iowa State Archeologist
Iowa State University
Southern Iowa Conservancy District
Missouri Office of Administration
Missouri Department of Agriculture
Missouri Department of Conservation
Missouri Department of Natural Resources
Missouri Department of Consumer Affairs
University of Missouri
University of Missouri Extension Service

F. Inventory And Analysis Reports

The following list of Inventory and Analysis Reports were prepared as working documents. They are technical reports, developed during the study (1976-79), valuable to persons needing this detail. Copies of a part or all of each draft report are available from the Soil Conservation Service. For copies or additional information contact the State Conservationist, Soil Conservation Service, 555 Vandiver Drive, Columbia, Missouri 65201.

	Number of Pages in Report
Economic Projection	34
Forestry Inventory	18
Water Supply	50
Water Quality	115
Flooding Tarkio Subbasin	43
Flooding Nodaway Subbasin	45
Flooding Platte Subbasin	81
Flooding Upper Grand Subbasin	110
Flooding Thompson Subbasin	62
Flooding Lower Grand Subbasin	91
Flooding Chariton Subbasin	91
Flooding Direct Tributaries	55
Erosion and Sediment	140
Irrigation Inventory	70
Agricultural Land	192
Agricultural Land, Appendix A: Documentation of Programs	37
Agricultural Land, Appendix B: Analysis of Erosion Reduction Practices	81

CHAPTER I

BASIN RESOURCES

I. BASIN RESOURCES

A. Description

The Northern Missouri River Tributaries Basin includes the drainage areas of the Tarkio, Nodaway, Platte, Grand, and Chariton Rivers, which originate in Iowa and flow south across Missouri into the Missouri River. The remainder of the basin is drained by streams originating in Missouri and flowing directly into the Missouri River (Map 1).

The streams and rivers of the basin drain 4,988 square miles in Iowa and 13,551 square miles in Missouri or a total of 18,539 square miles. It includes 13 U.S. Water Resources Hydrologic Units (Table 1).

Table 1 -- Drainage Areas, Northern Missouri River Tributaries Basin, Iowa and Missouri (U.S. Water Resources Council)

Hydrologic Units	Descriptions	Drainage Areas Iowa Sq. Mi.	Missouri Sq. Mi.	Total Sq. Mi.
10240005	Tarkio River	327	1041	1368
10240011	Smaller Trib's to Missouri River	---	399	399
10240009	Nodaway River	813	---	813
10240010	Nodaway River	417	590	1007
10240012	Platte River	398	1280	1678
10240013	102 River	388	353	741
10280101	Upper Grand River	507	2760	3267
10280102	Thompson River	1106	1099	2205
10280103	Lower Grand River	125	2283	2408
10280201	Upper Chariton River	907	439	1346
10280202	Chariton River	---	1033	1033
10280203	Little Chariton River	---	704	704
10300101	Direct Tributaries to the Missouri River	---	1570	1570
	TOTALS	4988	13551	18539

The basin area includes eight Iowa counties which are entirely within the basin and partial areas of 12 others. In Missouri, 22 counties are entirely within the basin and 6 others are partially in the basin (Table 2).

Mean sea level ranges from 1,160 feet in the headwaters to 600 feet near the southeast corner of the basin. Topography over most of the basin area is rolling

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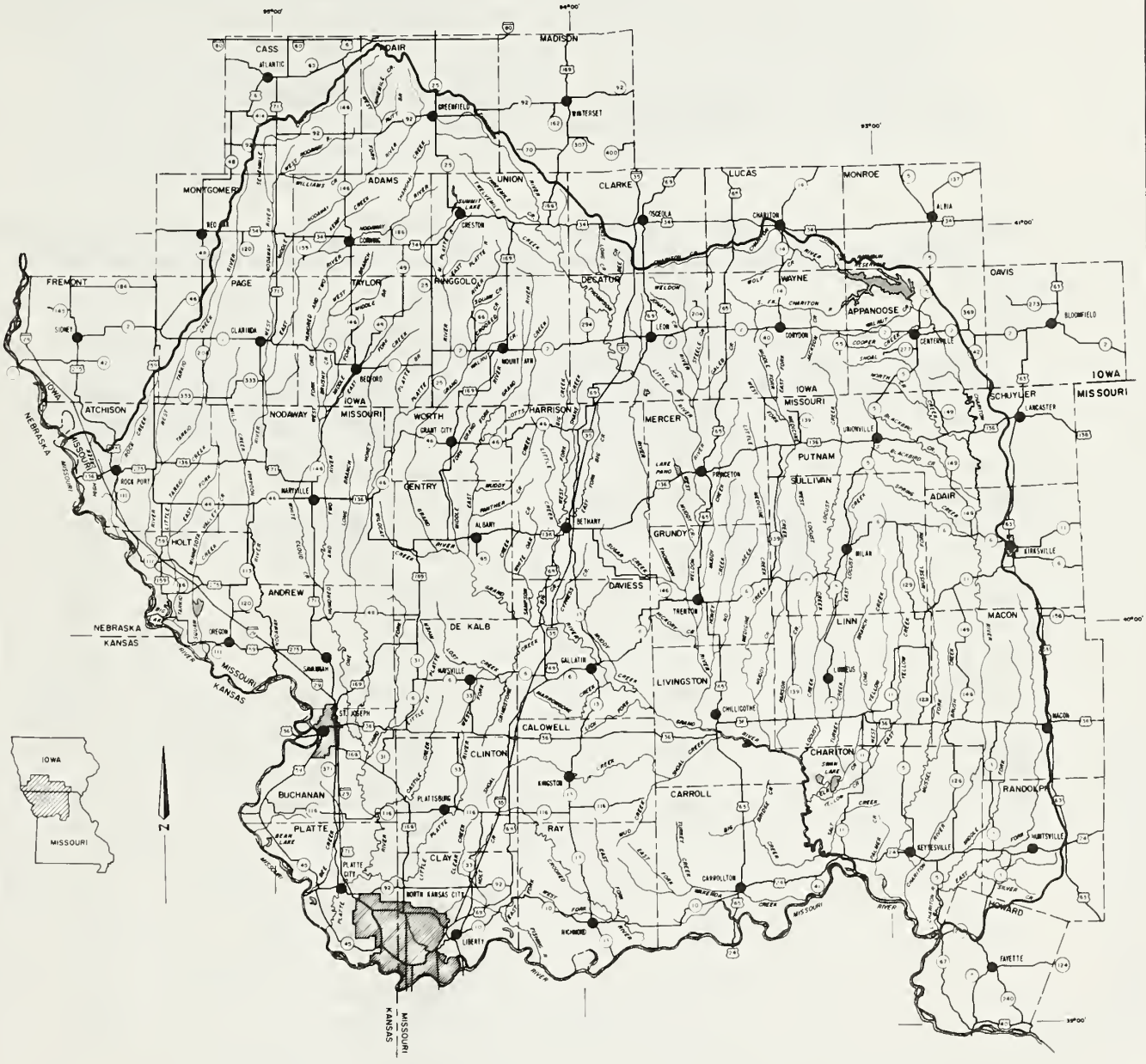


LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- COUNTY SEATS & TOWNS OVER 15,000
- DRAINAGE
- LAKES
- INTERSTATE HIGHWAY
- U.S. HIGHWAY
- STATE HIGHWAY
- BASIN BOUNDARY

MAP I
AREAL MAP

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

MISSOURI AND IOWA

SCALE 0 10 20 30 40 50 MILES
0 10 20 30 40 50 60 70 80 KILOMETERS

SOURCE
SCS DRWG NO. 5.R-35,055 (REV 2-80)
LAMBERT CONFORMAL CONIC PROJECTION

2-29-80
5.0-37,748 4

to hilly with some areas level to undulating. Hilly to steep ridge and valley slopes occur along major streams. Interstates 29 and 35, and U.S. 59, 71, 169, 69, 65 and 63 are north-south highways. Interstate 80 and U.S. 6, 24, 136 and 36 are east-west highways.

Table 2 -- Counties, Northern Missouri River Tributaries Basin, Iowa and Missouri

IOWA		MISSOURI	
County	Area in Basin Percent	County	Area in Basin Percent
Adair	68	Adair	53
Adams	100	Andrew	100
Appanoose	87	Atchison	87
Audubon	94	Buchanan	100
Cass	100	Caldwell	100
Clarke	31	Carroll	100
Davis	7	Chariton	100
Decatur	100	Clay	100
Fremont	72	Clinton	100
Guthrie	6	Daviess	100
Lucas	31	DeKalb	100
Madison	5	Gentry	100
Mills	59	Grundy	100
Monroe	2	Harrison	100
Montgomery	100	Holt	100
Page	100	Howard	10
Ringgold	100	Linn	100
Taylor	100	Livingston	100
Union	98	Macon	64
Wayne	100	Mercer	100
		Nodaway	100
		Platte	100
		Putnam	100
		Randolph	57
		Ray	100
		Schuyler	33
		Sullivan	100
		Worth	100

The basin can be characterized as a typical midwestern rural area with scattered small towns and a low population density. The largest city is St. Joseph, Missouri, with a population of 76,691 in 1980. The cities with populations of over 2,000 are usually the county seats. Kansas City, Missouri, lies just outside of the basin to the southwest. Spillover of residential and commercial development from Kansas City is occurring into the basin area.

B. Climate

Climatically, the area is characterized by warm, humid summers and cold winters. Within a season, temperatures and precipitation may fluctuate widely. Cold

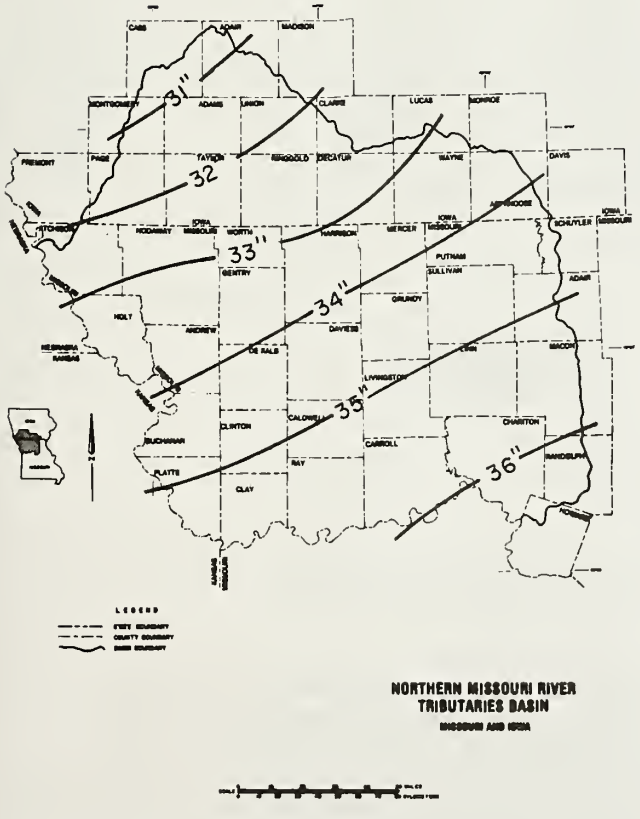
air moves into the basin from the north out of Canada; and warm, moist gulf air moves into the basin out of the Gulf of Mexico.

Summer weather is moderately warm and humid. July and August temperatures occasionally exceed 100 degrees Fahrenheit. Average annual temperatures range from 49 degrees Fahrenheit in the north to 55 degrees Fahrenheit in the south. The frost-free period extends from April through late October, ranging from an average of 190 frost-free days in the northwest to an average 214 frost-free days in the southeast.

Winter weather is cold, with several days of subzero temperatures. The average winter temperatures range from 23 degrees Fahrenheit in Iowa to 31 degrees Fahrenheit in Missouri. The regional average for January is 26.8 degrees Fahrenheit.

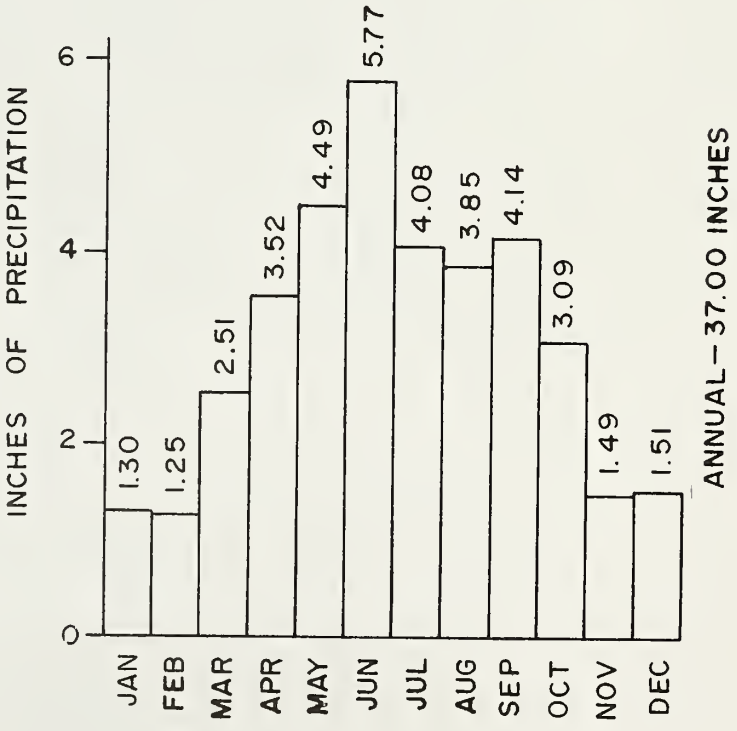
The average annual recorded precipitation measurements range from 31 inches in the northwest part of the basin, to 36 inches in the southeast part (Map 2). The average annual regional rainfall for the basin is 37 inches. The monthly regional distribution varies from 1.25 inches in February to 5.77 inches in June (Figure 1).

Map 2
Average Annual Rainfall



Average annual rainfall increases southeasterly across the basin.

Figure 1 -- Missouri Regional Average Monthly Rainfall Distribution



Maximum average rainfall occurs in June. November, December, January, and February are months of minimum rainfall.

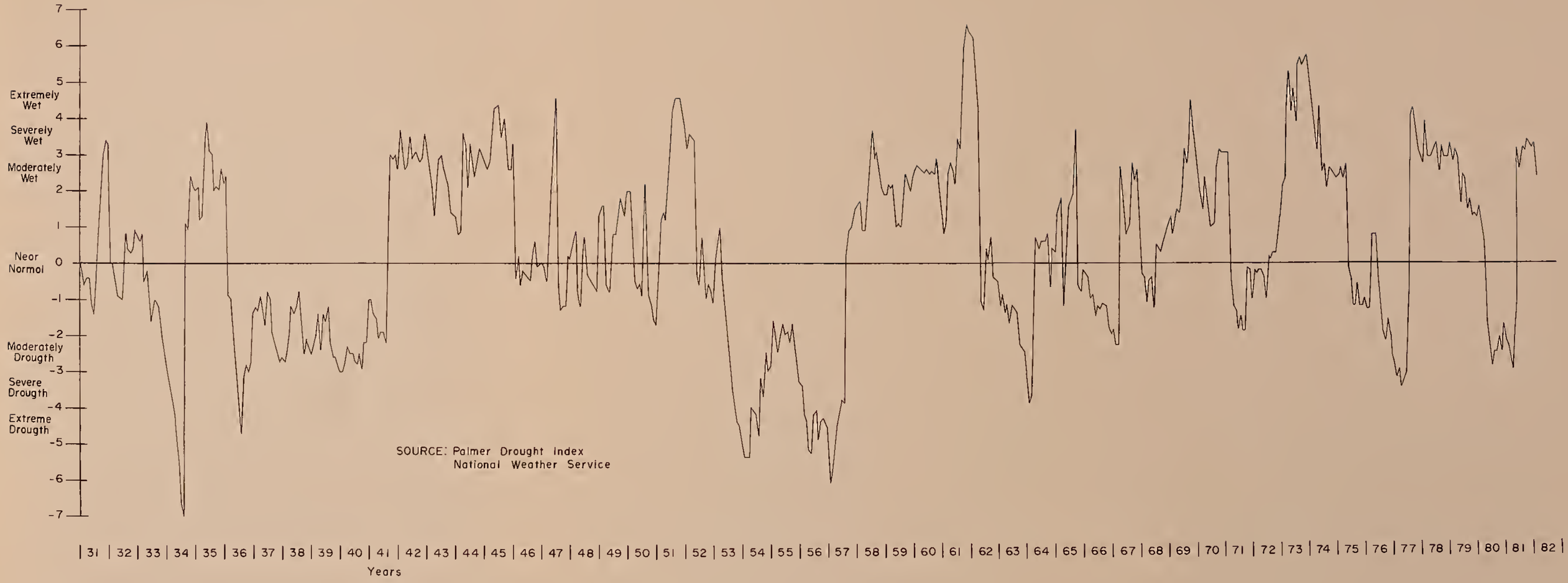
Evaporation and transpiration are important to stream-low-flow characteristics and depletion of ground water aquifers and surface reservoirs. Annual net lake evaporation ranges from 2 inches in the eastern part of the basin to 8 inches in the western part (Map 3). Seventy-six percent of the evaporation occurs between May and October. During July, average evapotranspiration values amount to about .27 inches per day.

Map 3 -- Lake Evaporation.

Lake evaporation decreases easterly across the basin.

The distribution of rainfall during the growing season is usually favorable to growing crops. Short drought periods occur most years, normally during July and August; and frequently subnormal annual precipitation results in a need for supplemental water for full crop production. Two periods of extended severe drought have occurred during the period 1931 through 1978. One of these periods occurred in the mid 1930's and the other in the mid 1950's (Figure 2).

Figure 2 — Drought and Wet Spell Periods for Missouri Northwest Prairie Climatic Division, Northern Missouri River Tributaries Basin, Missouri



C. Land Resources

Geologic processes are recorded in the bedrock, were operative in the placement of mineral resources, and continue into the present time in the development of soils. Thus, the basin's resources are but a continuum of time. Man has separated resources for ease in classifying, studying, understanding, and using. These separations are discussed in this section.

Geology

Mississippian, Pennsylvannian, and Cretaceous age rocks form the bedrock underlying the basin (Map 4). These sedimentary rocks formed over long geologic intervals. The area was beneath shallow seas for most of this geologic time.

Stone, sand and gravel, clay, and shale operations occur throughout the basin. In addition, there are major underground limestone mines in the Kansas City area.

Although coal bearing strata underlie the entire basin, present coal mining is restricted to a tier of Missouri counties along the eastern edge of the basin. In the foreseeable future, these counties; Putnam, Schuyler, Adair, Macon, and Randolph; will remain the active areas of coal mining.

Soils and Geology

Soils in the basin are formed in loess, glacial till, alluvium, residual material, or in a combination of these parent materials. Predominant soils in the basin have been grouped by parent material, slope, and soil texture into soil associations (Maps 5 and 6). Some of the boundaries and soil names on the two soil maps do not match. The differences are a result of correlation decisions that reflect local variations in survey area and the extent of soils within a survey area. In some places, it is more feasible to combine small areas with similar soils than it is to separate the soils and give them different names.

Detailed soil maps and information on soils and specific uses are available for some of the basin through the Soil Conservation Service. In the Missouri part of the basin, as of January 1981, modern soil surveys had been completed in ten counties. Seven of these counties have published soil surveys.

Continental glaciers advanced and retreated over the bedrock, leaving thick deposits. Deposits from the final continental glaciation, the Kansan, covered earlier deposits. When the Kansan glaciation ceased, the area was covered with a relatively level drift plain. Following the Kansan glaciation, a thick layer of windblown silt, called loess, was deposited over most of southern Iowa and the Missouri portion of the basin. Loess in the western portion of the basin possibly has its origin in the flood plain of the Missouri River. Loess in the eastern portion of the basin may have been derived from other sources.

Deep soils developed on these upland surfaces. The basin has since been dissected and only remnants of old surfaces remain.

U. S. DEPARTMENT OF AGRICULTURE

LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- COUNTY SEATS & TOWNS OVER 15,000
- DRAINAGE
- LAKES
- INTERSTATE HIGHWAY
- U.S. HIGHWAY
- BASIN BOUNDARY

QUATERNARY

PLEISTOCENE SERIES
Alluvium, clay, silt, sand, and gravel.

CRETACEOUS

GULFIAN SERIES
Sandstone and shale with minor limestone.

PENNSYLVANIAN

VIRGILLIAN SERIES
Cyclic deposits, shale, limestone, siltstone, and thin coal seams.

MISSOURIAN SERIES
Cyclic deposits, limestone, shale, and sandy shale.

MOBERLY SANDSTONE
A thick channel sandstone.

DESMOINESIAN SERIES
Cyclic deposits, limestone, shale, sandstone, and coal beds.

MISSISSIPPIAN

OSAGEAN SERIES
Cherty, crinoidal limestone.

MAP 4

GENERALIZED BEDROCK GEOLOGY

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

MISSOURI AND IOWA

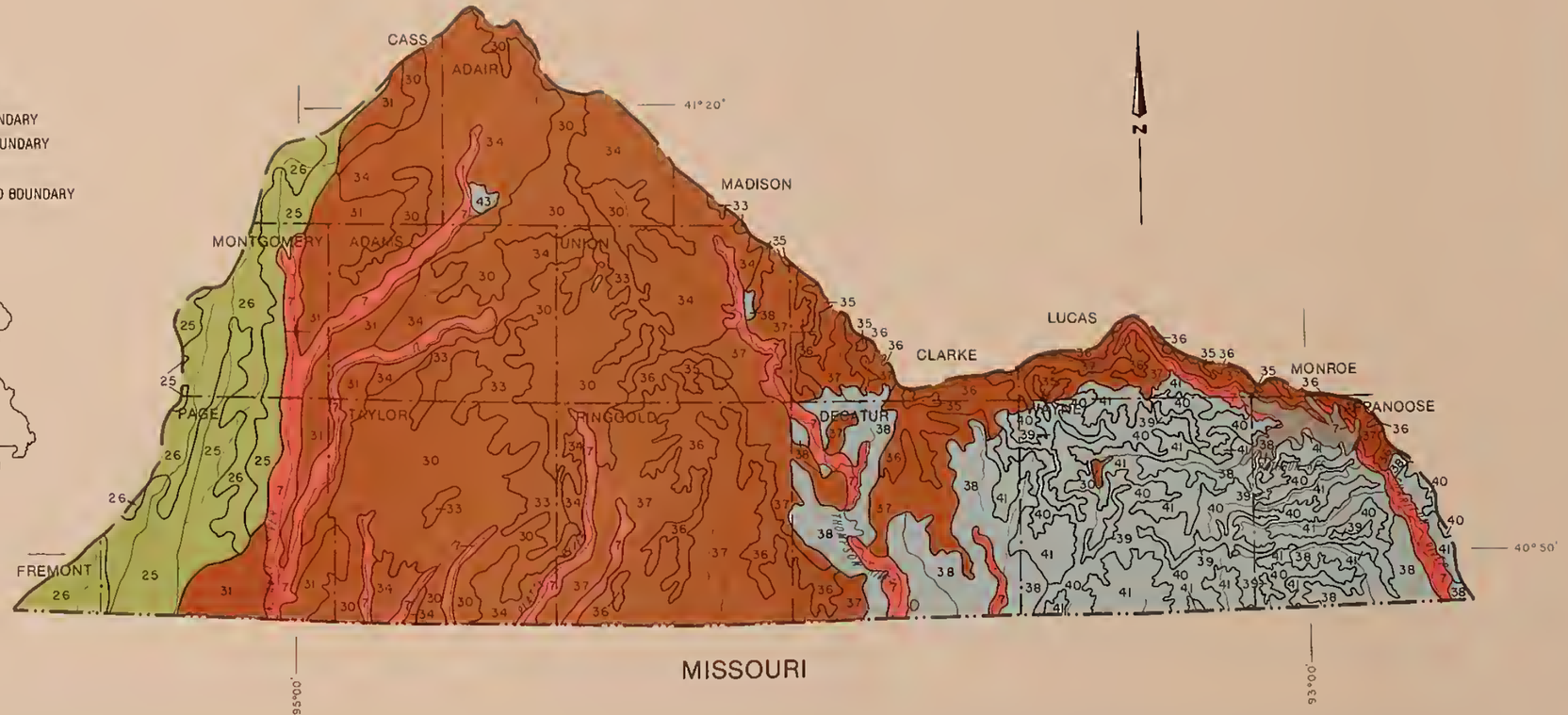
SOURCE
FAMILY OF MAPS SCS DRWG NO. S,R-35,015,2 (R) AND INFORMATION FROM MISSOURI AND IOWA STATE GEOLOGIC MAPS
LAMBERT CONFORMAL CONIC PROJECTION

REV 6-26-78
S,R-36,842

USDA-SCS-LINCOLN, NEBR. 1980

BASE LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- DRAINAGE
- WATERSHED BOUNDARY



SOIL ASSOCIATIONS

25	MARSHALL - SHELBY - ADAIR
26	MARSHALL
	SHARPSBURG - SHELBY - ADAIR
	SHELBY - SHARPSBURG - ADAIR
	SHARPSBURG - MACKSBURG - WINTERSET - CLARINDA
34	SHELBY - ADAIR - SHARPSBURG
	GRUNDY - HAIG
	GRUNDY - HAIG - SHELBY - ADAIR
	ADAIR - SHELBY - LINDLEY - GRUNDY
38	LINDLEY - WELLER
39	EDINA - SEYMOUR
40	SEYMOUR - EDINA - CLARINDA - ADAIR - SHELBY
41	SHELBY - ADAIR - LINDLEY - SEYMOUR
43	LINDLEY - CLINTON
7	COLO - ZOOK - NODAWAY

MAP 5

GENERAL SOIL MAP

IOWA

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN
IOWA AND MISSOURI

SCALE 0 10 20 30 40 50 MILES; 0 10 20 30 40 50 60 70 80 KILOMETERS

SOURCE:
SCS DRAWING NO. 5,S-32,928 (11-74),
IOWA SOIL ASSOCIATION MAP (3-78) AND
INFORMATION FROM SCS FIELD PERSONNEL
ALBERS EQUAL AREA PROJECTION

1-23-80
5,S-37,737

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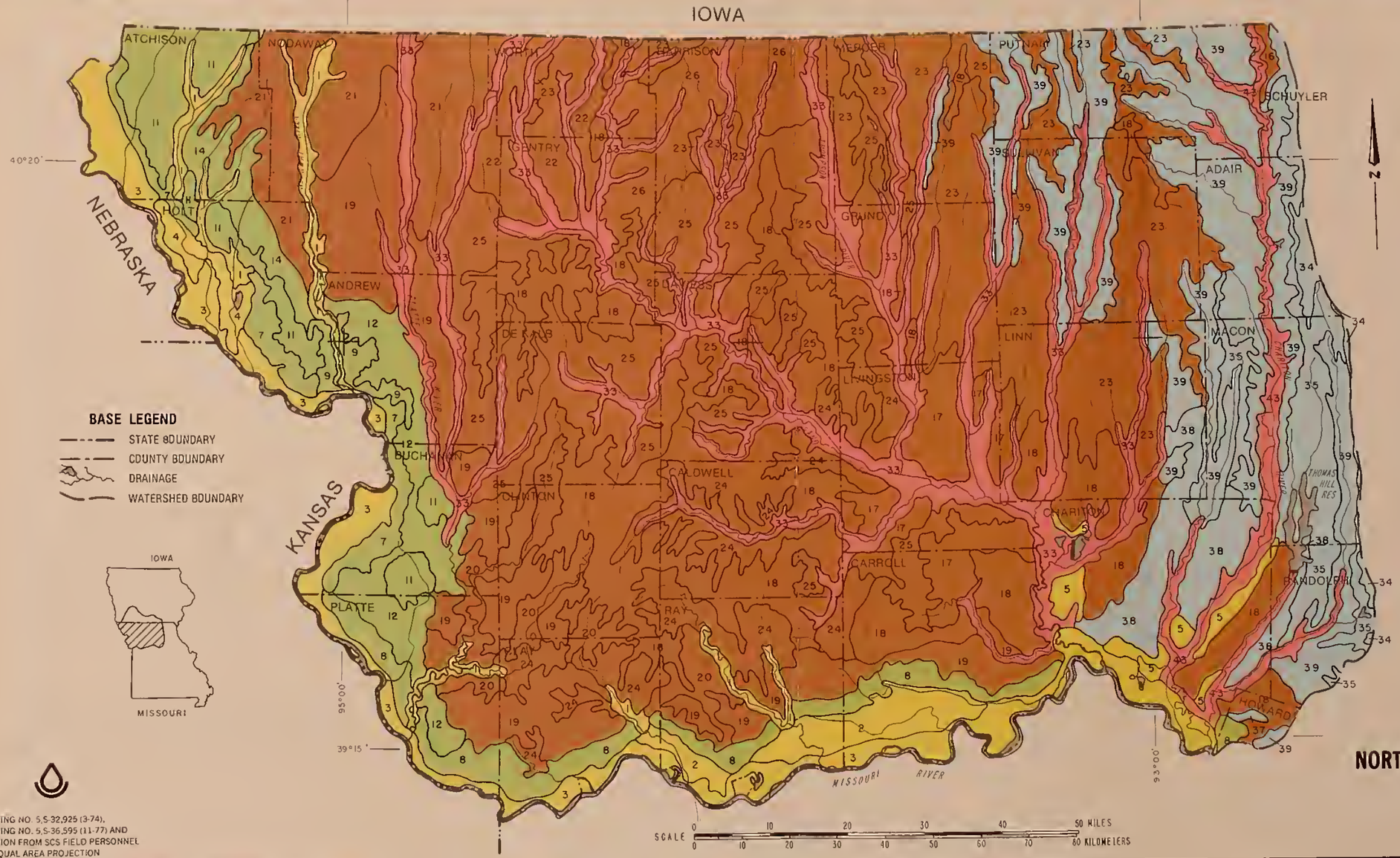
SOIL CONSERVATION SERVICE



BASE LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- DRAINAGE
- WATERSHED BOUNDARY

SOIL ASSOCIATIONS

1	KENNEBEC - ZOOK - BLACKOAR
2	BUCKNEY - NORBORNE - LETA - BOOKER
3	HAYNIE - LETA - WALDRON
4	HAYNIE - BLAKE - BOOKER
5	CHARITON - BREMER
7	KNOX - JUDSON - MCPAUL
8	KNOX - MARSHALL - KENNEBEC
9	KNOX - MANDEVILLE - NODAWAY
11	MARSHALL - JUDSON - KENNEBEC
12	MARSHALL - LADOGA - GARA
14	MARSHALL - SHELBY - COLO
16	KILWINNING - LAMONI - ARMSTER
17	SEYMOUR - LAGONDA
18	GRUNDY - LAGONDA
19	SHARPSBURG - HIGGINSVILLE - LAMONI - SHELBY
20	SHARPSBURG - GARA - ZOOK
21	SHARPSBURG - ADAIR - SHELBY - COLO
22	SHARPSBURG - LAGONDA - SHELBY
23	PERSHING - ARMSTRONG - GARA
24	LAGONDA - LAMONI - ARMSTER - SNEAD
25	LAMONI - SHELBY - ZOOK
26	ADAIR - SHELBY - ZOOK
34	PUTNAM - MEXICO
35	MEXICO - LEONARD - ARMSTRONG - LINDLEY
37	MENFRO - WINFIELD - LINDLEY
38	LAGONDA - KESWICK - LINDLEY
39	WELLER - KESWICK - LINDLEY - MANDEVILLE
33	KENNEBEC - NODAWAY - COLO - ZOOK
43	ARBELA - PIOPOLIS - BLACKOAR

SOURCE:
SCS DRAWING NO. 5,S-32,925 (3-74),
SCS DRAWING NO. 5,S-36,595 (11-77) AND
INFORMATION FROM SCS FIELD PERSONNEL
ALBERS EQUAL AREA PROJECTION

SCALE 0 10 20 30 40 50 MILES
0 10 20 30 40 50 60 70 80 KILOMETERS

MAP 6

GENERAL SOIL MAP

MISSOURI

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

IOWA AND MISSOURI

1-10-80
5,S-37,736

Land Classification

The basin is in the Central Feed Grain and Livestock Region (Source: Agriculture Handbook 296). Fertile soils and favorable climate make this region one of the outstanding grain producing regions of the world. It contains four Major Land Resource Areas (Map 7). Major Land Resource Areas (MLRA's) are broad geographic areas having similar soil, climatic, geologic, vegetative, and topographic features. MLRA's in the basin are 107, 108, 109, and 115.

MLRA 107 - Iowa and Missouri Deep Loess Hills

This loess-mantled glacial till plain is rolling to hilly. The ridgetops and broad uplands far from the large streams are level to gently sloping.

Thickest deposits of loess are along the river bluffs, and the deposits become thinner with increasing distance from the bluffs. Missouri River bottom land and narrow valleys issuing from the upland contain alluvium.

The upland soils are mostly deep, silty soils on moderate to steep slopes, which are easily eroded. The bottom lands contain loamy and clayey soils that are subject to flooding.

A typical landscape consists of small to medium irregular-shaped cultivated fields on gently sloping ridgetops and nearly level bottom lands. There are pastures on the steeper side slopes, and trees in the narrow valleys.

MLRA 108 - Illinois and Iowa Deep Loess and Drift

Deep loess deposits occur on nearly level to rolling to hilly topography. The small streams have narrow valley floors, but the large streams have broad flood plains.

The soils on the steeper eroded upland and side slopes are developed in loess and exposures of glacial till and are subject to severe erosion. Soils on the nearly level topography or in depressions have clayey subsoils that are often wet in the spring and winter months. Soils on the nearly level flood plains vary from poorly drained soils developed in clayey sediments to moderately well drained soils and loamy or silty sediments.

A typical landscape area consists of broad-cultivated fields on the nearly level area to small to medium irregular-shaped cultivated fields on the ridgetops. Pastures are on the steeper side slopes, while the narrow valleys are commonly wooded.

MLRA 109 - Iowa and Missouri Heavy Till Plain

A thin loess mantle overlies glacial till on the upper ridges while till is the common material on foot slopes. Slopes are mostly rolling to hilly, but some broad ridgetops are nearly level to undulating. Areas bordering major stream valleys have the steeper slopes; nearly level alluvial areas border streams.

LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- BASIN BOUNDARY
- MLRA BOUNDARY

MAP 7
MAJOR LAND RESOURCE AREAS
NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA

Upland soils are mostly deep and loamy and have pronounced slopes that are subject to severe erosion. Bottom land soils are loamy and clayey and subject to flooding.

A typical landscape area is broad cultivated fields on the ridges and in wide valleys, while cultivated fields, pastures, and trees dominate the steeper slopes.

MLRA 115 - Central Mississippi Valley Wooded Slopes

This area of deep loess occurs on rolling narrow ridgetops and steep valley slopes.

Ridgetops are deep silty soils near the Missouri River and deep loamy and cherty soils on ridges at a distance from the Missouri River. Deep silty, loamy and clayey soils are on the benches and flood plains of streams.

A typical landscape consists of small cultivated fields on gently sloping ridgetops and upper side slopes with areas of pasture and forest on the side slopes.

Present Land Use and Future Demands

Land use in the basin is discussed as total, inventory, noninventory, upland, bottom land, and flood plain. All of these groupings of land use except flood plain were compiled from Conservation Needs Inventory data. Inventory land, consisting of cropland, permanent pasture, forest, and other, has been further subdivided elsewhere in the report (Table 3). Noninventory land has been grouped as urban, federal, and water. Upland and bottom land groupings of land use were compiled by alluvial and nonalluvial soil groupings of CNI data. In addition, 672,039 acres of Missouri River bottom land are included in the percentage of bottom land in the basin. The flood plain acreages shown elsewhere in the report were compiled for economic evaluations of flood damages. Bottom land areas that flood less frequently than once every hundred years were not included in flood plain acreage compilations.

The basin is primarily a rural area. The predominant land use is cropland (Figure 3a). Present estimated land use for Iowa and Missouri is summarized to display the acres of major land uses by hydrologic units (Table 3).

The dominant use of land resources is for the production of food and fiber. About 94 percent of the 8.673 million acres in the Missouri portion of the basin is used for this purpose (Figure 3b). The principal crops are soybeans, corn, hay, and pasture (Figure 3c).

The land base for agricultural production in the Missouri portion of the basin consists of 77 percent upland soils and 23 percent bottom land soils (Table 4). Over half the bottom land soils are used for row crop production compared to 28 percent for the upland soils. Dominant use of upland soils is for the production of hay and pasture which supports the extensive cattle industry. Forested land occupies about 16 percent of both bottom land and upland soils.

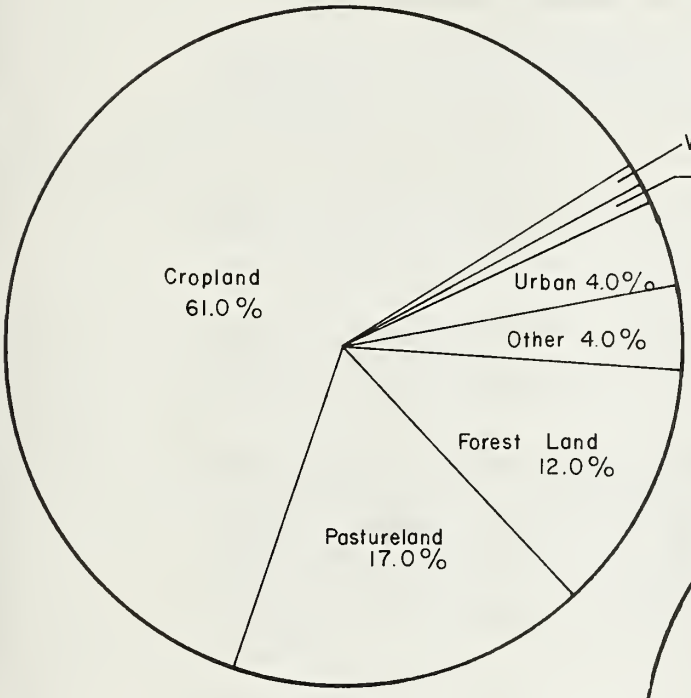
Cropland acreage decreases eastward across the basin. This decrease is not uniformly distributed in the subbasins. The lower halves of the eastern subbasins have more cropland than the upper halves. Cropland harvested acreage increased in the basin until 1920. A sharp decline in cropland harvested acreage occurred from 1920 to 1930 and continued to decline at a lesser rate until 1970. Since 1970, cropland harvested acreage has generally increased while idle acreage, pasture and forest land, has decreased. The most significant change in land use in recent years has been the rapid increase in soybean acreage. Soybean acreage increased from about 100,000 acres in 1949 to the current level of about 1,400,000 acres. During this period, corn acreage decreased about 150,000 acres and wheat acreage decreased 200,000 acres.

Farm income statistics reflect the rapid expansion of soybean production. In 1949, crops accounted for only 17 percent of the income from the sale of farm products. By 1974, crops accounted for almost half of the gross

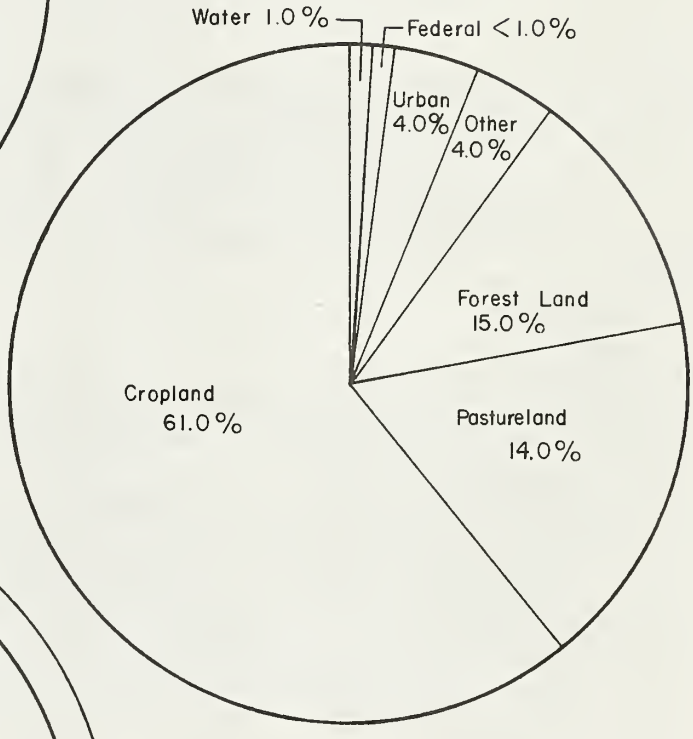
Table 3 -- Present Estimated Land Use, Northern Missouri River Tributaries Basin, Iowa and Missouri

HYDROLOGIC UNIT CODES	SUBBASIN DESCRIPTIONS	STATE	LAND USE							
			INVENTORY LAND				NONINVENTORY			
			Cropland	Pasture	Forest	Other	Urban	Federal	Water	Subtotals
			ACRES							
10240005	Tarkio River	Iowa	157,170	31,540	4,400	7,030	7,510	-	1,650	209,300
10240011	Smaller Missouri River Trib's	Missouri	608,000	70,000	84,000	66,500	63,000	6,370	23,900	921,770
10240009	Nodaway River	Iowa	572,860	148,060	15,840	20,700	27,100	-	2,640	787,200
10240010	Nodaway River	Missouri	244,800	47,700	49,000	20,600	13,000	1,500	1,000	377,600
10240012	Platte	Iowa	322,650	134,920	17,860	8,750	18,330	-	490	503,000
10240013	102 River	Missouri	621,700	129,900	159,000	53,000	75,540	800	5,500	1,045,440
10300101	Direct Trib's to Missouri River	Missouri	540,000	134,000	139,000	51,100	110,000	3,800	27,000	1,004,900
10280101	Upper Grand River	Iowa	198,730	89,100	16,680	7,160	12,970	-	1,420	326,060
		Missouri	1,172,700	193,000	286,000	56,600	49,100	-	9,000	1,766,400
10280102	Thompson River	Iowa	396,400	219,870	49,220	13,610	26,010	-	860	705,970
		Missouri	393,700	118,400	136,000	28,300	22,260	-	4,700	703,360
10280103	Lower Grand River	Iowa	46,680	23,780	3,320	2,570	3,750	-	170	80,270
		Missouri	895,900	260,900	213,000	45,200	25,950	3,200	17,000	1,461,150
10280201	Upper Chariton R.	Iowa	292,190	161,950	42,130	20,960	22,120	29,220	11,830	580,400
10280202	Chariton River	Missouri	745,600	292,600	244,400	61,900	34,180	5,000	8,700	1,392,380
10280203	Little Chariton R.									
		TOTALS	7,209,080	2,055,720	1,459,850	463,980	510,820	49,890	115,860	11,865,200
		Upland	76%	87%	81%	86%	-	-	-	79%
		Bottom Land	24%	13%	19%	14%	-	-	-	21%

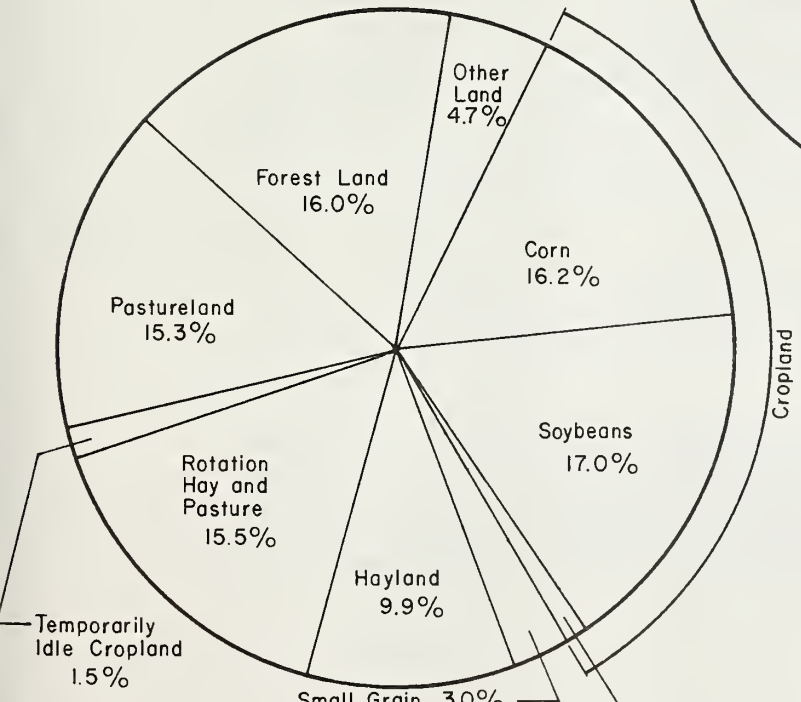
Figure 3 -- Missouri Agricultural and Forestry Land Use, Inventory Land, Northern Missouri River Tributaries Basin. (CNI Data Adjusted 1978)



3a
LAND USE
(ENTIRE BASIN)



3b
LAND USE
(MISSOURI PORTION
OF BASIN)



3c
PRINCIPAL CROPS
(MISSOURI PORTION
OF BASIN)

Table 4 -- Missouri Agricultural Land Use - Inventory Land, by Upland and Bottom Land, Northern Missouri River Tributaries Basin. (CNI Data Adjusted 1978)

Item	Upland		Bottom Land		Total	
	Acres (1000)	Percent	Acres (1000)	Percent	Acres (1000)	Percent
Cropland						
Corn	872.5	13.8	452.7	24.5	1325.2	16.2
Sorghum	45.4	.7	23.5	1.3	68.9	.9
Soybeans	851.4	13.5	533.4	28.9	1384.8	17.0
Other Row	1.9	--	.2	--	2.1	--
Total Row Crops	1771.2	28.0	1009.8	54.7	2781.0	34.1
Wheat	126.9	2.0	72.7	3.9	199.6	2.4
Oats	34.1	.5	10.9	.6	45.0	.6
Other Sm. Grain	2.2	.1	.7	--	2.9	--
Total Small Grain	163.2	2.6	84.3	4.5	247.5	3.0
Alfalfa Hay	294.8	4.7	22.3	1.2	317.1	3.9
Other Hay	431.4	6.8	58.2	3.2	489.6	6.0
Cropland Pasture	1128.4	17.9	140.6	7.6	1269.0	15.5
Total Forage	1854.6	29.4	221.1	12.0	2075.7	25.4
Idle and Other	89.3	1.4	28.9	1.6	118.2	1.5
Total Cropland	3878.3	61.4	1344.1	72.8	5222.4	64.0
Permanent Pasture	1101.8	17.4	144.7	7.8	1246.5	15.3
Forest Land	1023.2	16.2	287.2	15.6	1310.4	16.0
Other Land	312.3	5.0	70.9	3.8	383.2	4.7
Total Inventory	6315.6	100.0	1846.9	100.0	8162.5	100.0

income. During this period, poultry, swine, and dairy production decreased significantly while beef cattle production increased.

Rapid adoption of labor efficient technology has resulted in increased farm output from fewer but larger farms. The number of farms decreased by 36 percent from 1954 to 1974 while the average size increased from 187 to 275 acres per farm.

Many of the farmers have other sources of income and employment. In 1974, 32 percent of the farm operators had principal occupations other than farming and 44 percent had other sources of income.

Most of the farmers own all or part of their farms. In 1974, 63 percent were full owners, 26 percent were part owners, and 11 percent were tenants. The average age of all operators was 52 years.

Demand for all major crops grown in the area is expected to increase (Table 5). The exception is oats, which is presently not considered a major crop. The demand for corn, soybeans, and sorghum is expected to exceed projected production. Yields for wheat, oats, hay, and pasture are projected to continue at a greater rate than demand. If these projected events occur, conversion of pasture, hay, and small grains to row crops is expected to continue.

Prime Farmland

Prime farmland is defined as land that has the best combination of physical and chemical characteristics for producing food, feed, fiber, forage, and all seed crops, and is available for those uses. Prime farmland has the soil quality, growing season and moisture supply to economically sustain high yields of crops with treatment and good modern management. Prime farmlands are not excessively eroded or saturated with water for long periods of time and either do not flood or are protected from flooding. Slopes on prime farmland seldom exceed 5 percent. A detailed discussion of the criteria for prime farmland is available in Land Inventory and Monitoring Memorandum 3 (Revision 1) of the U.S. Soil Conservation Service dated August 16, 1977.

The 1978 Missouri Resources Appraisal states there are approximately 12 to 13 million acres of prime farmland within the State of Missouri. There are approximately 3 million acres of prime farmland (Table 6) within the Missouri area of the basin.

Nearly 66 percent of prime farmland in the Missouri area of the basin is presently in cropland. Fifty-eight percent of prime farmland being used as cropland is bottom land, and 42 percent of prime farmland in cropland is on the upland. Forest land, in the Missouri area of the basin, is estimated to contain 342,000 acres of prime farmland.

Table 5 -- Projected Percentage Change In Yields and Production for Missouri, Northern Missouri River Tributaries Basin. 1/

CROP	YIELD		PRODUCTION	
	1985	2000	1985	2000
	- - - - - - -Percent Change - - - - - - -			
Corn	20	41	31	71
Sorghum	35	65	56	111
Soybeans	11	24	25	75
Wheat	20	36	14	24
Oats	16	32	-47	-76
Hay and Pasture	14	29	11	20

1/ Base Period - 1970-74

Table 6 -- Prime Farmland by Land Use in Missouri, Northern Missouri River Tributaries Basin.

	Prime Farmland		
Land Use	Acres	Percent Upland and Bottom Land	
Cropland	2,280,000	Upland	42%
		Bottom land	58%
Forest	342,000	Upland	21%
		Bottom land	79%
Pasture	259,000	Upland	46%
		Bottom land	54%
Other and Urban	131,000	Upland	51%
		Bottom land	49%
TOTAL	3,012,000	Upland	40%
		Bottom land	60%

D. Forest (Missouri)

Forest resources include timber, forage, recreational opportunities, wildlife, and soil and watershed protection. Only 15 percent or 1,310,400 acres of the Missouri portion of the basin is forested. Of the eight subbasins, the Thompson subbasin is the most heavily forested and the Tarkio subbasin is the least forested. Forest cover in general is lightest in the western reaches of the basin and heaviest in the eastern reaches. In general, forest land exists in small, isolated tracts and occupies the steeper slopes.

Forest resources receive relatively minor consideration in this agriculturally oriented area. In fact, approximately 2,850 acres of forest land are converted to agricultural land per year. Bulldozed timber is usually piled and burned. Virtually all the forest land is privately owned; only 0.8 percent is owned by government or industry.

The predominant tree species are upland oaks including white, red, scarlet, and black oak. Other species include hickory, black walnut, elm, ash, cottonwood, maples, and sycamore. These species are divided into four size classes: saw timber, pole timber, saplings and seedlings, and nonstocked areas. Saw timber and pole timber each cover 38 percent of the forest, while saplings and seedlings cover 6 percent and nonstocked areas, 18 percent of the forest.

The Basin's forests are in poor condition. Eighty percent of the forested area is either poorly stocked or nonstocked. About 45 percent of the total cubic volume found on forest land is attributed to rough or rotten trees and has no real commercial value. Net annual growth averages only 16 cubic feet per acre per year and occurs mainly on poor quality trees. This growth rate is far below that which could be expected under intensive management.

Livestock grazing occurs on nearly 66 percent of the forest land. Only a few timber stands provide adequate forage for grazing. Improper livestock grazing is the major source of disturbance to forest lands. Overgrazing destroys the protective forest floor and results in accelerated erosion. These overgrazed areas are the major source of sediment from forest land.

E. Water Resources

The quantity and quality of surface and ground water resources will determine the potential or limitation of developing irrigation, recreation, fisheries, and other water dependent resources.

Surface Water

The total area of water in the basin is approximately 116,000 acres (Table 3) of which approximately 97,000 acres are in Missouri (Table 7) and approximately 19,000 acres are in Iowa. Large reservoirs total 24,481 acres.

Table 7 -- Surface Water Area in Missouri, Northern Missouri River Tributaries Basin. (CNI Data Updated 1978)

Missouri Counties	Water Acres	Missouri Counties	Water Acres
Adair	3665	Holt	9737
Andrew	2537	Howard	6164
Atchison	1590	Linn	1432
Buchanan	5197	Livingston	3961
Caldwell	1345	Macon	2333
Carroll	6568	Mercer	2426
Chariton	6623	Nodaway	671
Clay	9590	Platte	4708
Clinton	5300	Putnam	6131
Daviess	3083	Randolph	551
DeKalb	1729	Ray	6050
Gentry	2025	Schuyler	950
Grundy	1597	Sullivan	1946
Harrison	2420	Worth	880
Subtotal	53,269	Subtotal	47,940
	TOTAL:	101,209 (Missouri counties)	
	ADJUSTED:	97,000 (Basin, Missouri)	

Large reservoirs in the basin include Rathbun (11,000 acres) in Iowa; Thomas Hill (4,500 acres), Thunderhead (1,000 acres), Long Branch (791 acres), and Smithville (7,190 acres) in Missouri.

Generally, surface waters are slightly alkaline, moderately mineralized, and very hard. They are used for municipal supplies, dilution of treated municipal wastes, and livestock watering.

Except for the East Fork of the Chariton River, the rivers and streams have better water quality than the Missouri River. All streams in the basin can be classified as calcium bicarbonate, with the exception of the lower ends of the East and Middle Fork Chariton Rivers, which can be classified as calcium sulfate.

Average annual runoff varies from 5 inches in the northwest to 9 inches in the southeast (Map 8).

Runoff in the basin varies seasonally from 2.6 percent of the total in December to 21 percent in June. Gage records for the Grand River (typical of those throughout the basin) at Gallatin, Missouri, show the average monthly distribution (Figure 4).

Map 8

AVERAGE ANNUAL RUNOFF

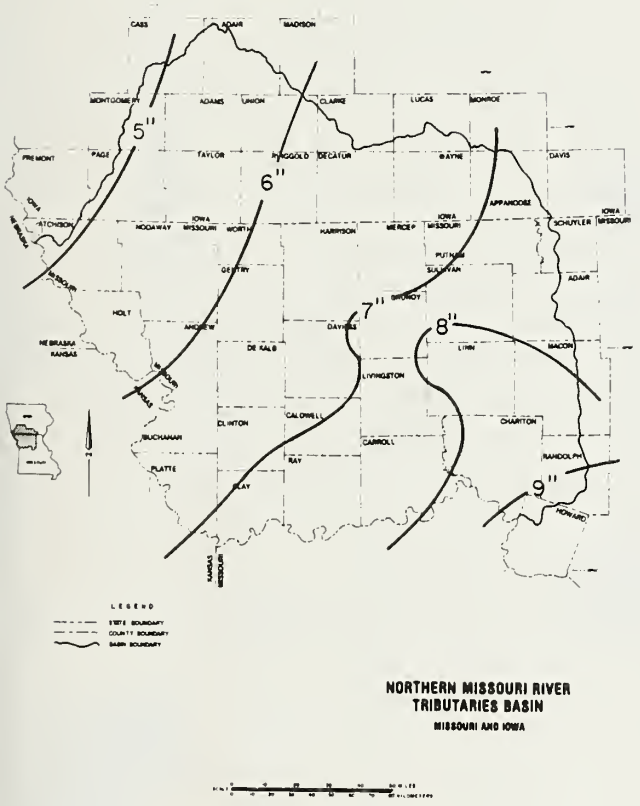
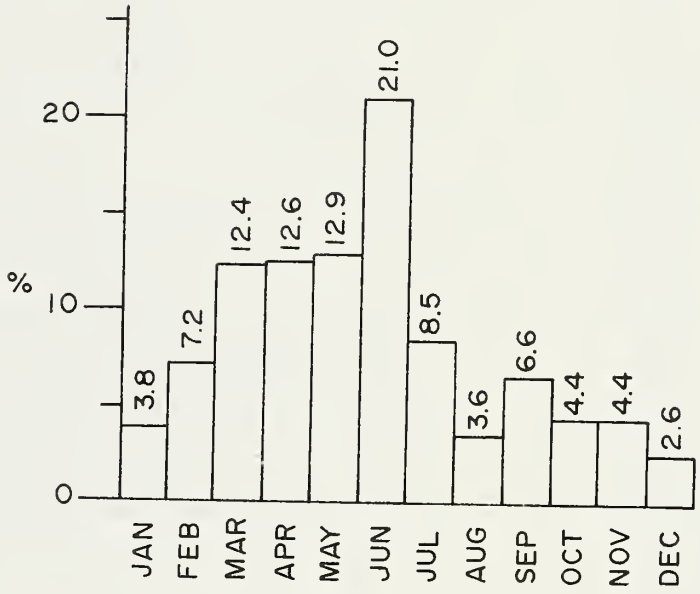


Figure 4 -- Average Annual Runoff by Months for the Grand River Gage at Gallatin, Missouri.



Average annual runoff increases southeasterly across the basin.

Average annual runoff measured at the Grand River Gage, Gallatin, Missouri is greatest during the month of June.

Ground Water (Missouri)

The volume of ground water stored in the basin is not known. Many ground water areas are poorly defined. The principal sources of ground water are alluvium, buried pleistocene valleys, glacial drift, and bedrock (Map 9).

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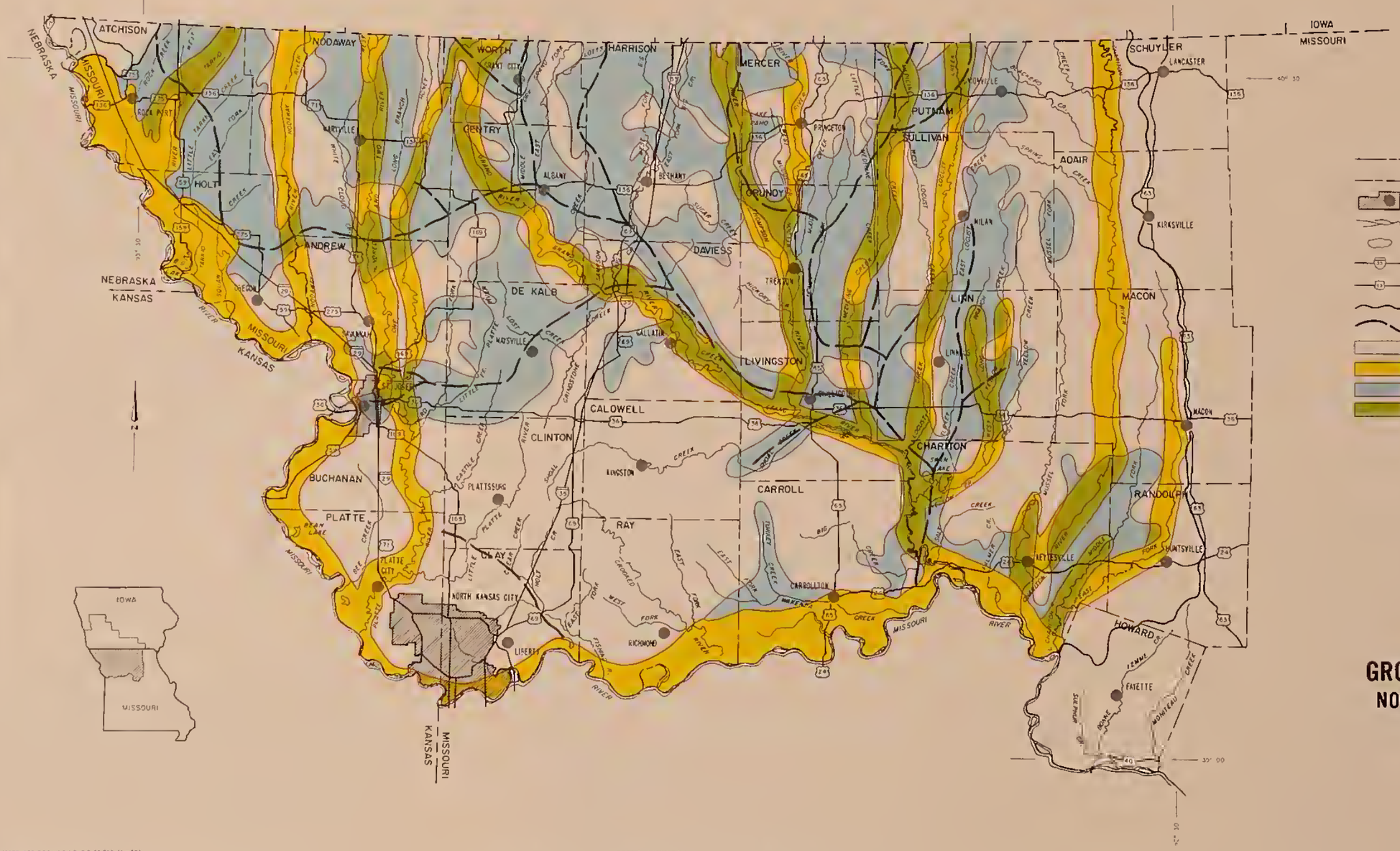


LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- COUNTY SEATS & TOWNS OVER 15,000
- DRAINAGE
- LAKE
- INTERSTATE HIGHWAY
- U.S. HIGHWAY
- BASIN BOUNDARY
- MAJOR PREGLACIAL DRAINS
- SURFICIAL MATERIALS ONLY
- RECENT ALLUVIUM
- BURIED ALLUVIUM
- BURIED & RECENT ALLUVIUM

MAP 9

GROUNDWATER SOURCES

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

MISSOURI

SCALE 1/900,000

SCALE 10 0 10 20 30 40 MILES

SOURCE:
FINAL DF MAPS SCS DRAWING NO. S.R-35,055 (1-78)
GROUNDWATER SOURCES ADAPTED FROM MISSOURI
GEOLOGICAL SURVEY AND WATER RESOURCE MAPS
AND INFORMATION FROM FIELD TECHNICIANS
LAMBERT CONFORMAL CONIC PROJECTION
USDA SCS LINCOLN NEBR (3X)

4-20-78
S.S-36,791

Water in the Missouri River alluvium is characterized by high hardness, high iron content, and a wide range in dissolved solids. Water in stream alluvium, other than the Missouri River alluvium, is characterized by moderate hardness, moderate iron content, and a moderate range in dissolved solids. The chemical water quality of ground water in buried pleistocene valleys and glacial drift is variable and may be better or worse in quality than ground water in the Missouri River or stream alluviums. In general, the water from buried pleistocene valleys and glacial drift is high in total iron, total dissolved solids, and sulfates. The dissolved-solids content of water from bedrock aquifers ranges from less than 1,000 to 20,000 mg/l, and sodium chloride and sulfate are usually the principal constituents. The high dissolved-solids content of bedrock aquifers makes them unsuitable for most uses. Waters with totally dissolved solids in the range 1,000 to 2,000 mg/l may have adverse effects on many crops and require careful management practices. Waters with totally dissolved solids in the range 2,000 to 5,000 mg/l can be used for tolerant plants on permeable soils with careful management practices. Waters with totally dissolved solids in excess of 5,000 mg/l are not recommended for irrigation.

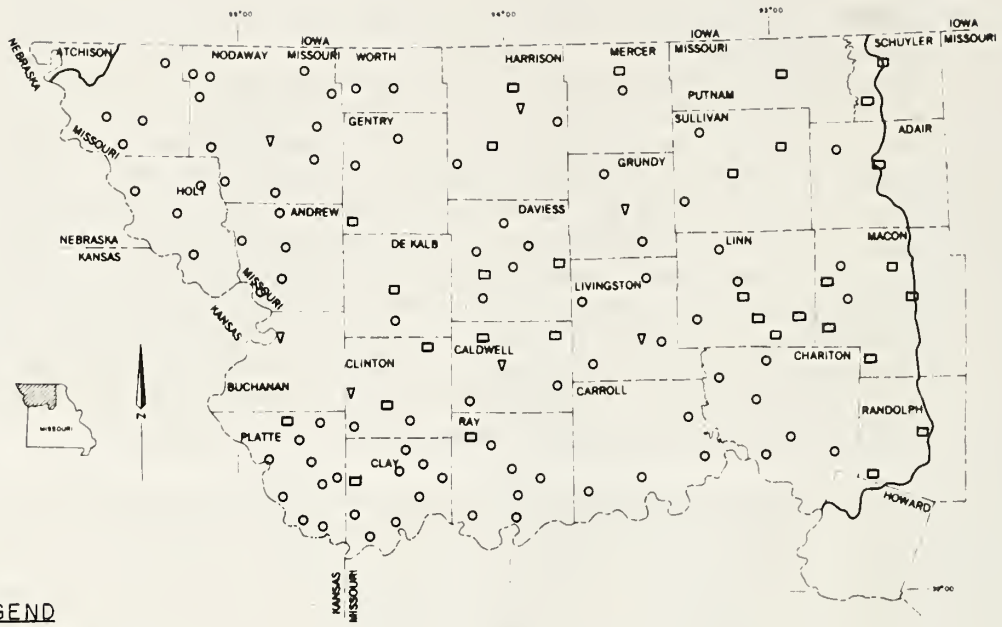
Ground water yields are the most dependable in the Missouri River alluvium where wells yield from 1,000 to 2,000 gallons per minute. The tributary alluvium wells yield from 10 to 175 gallons per minute but do not usually exceed 100 gallons per minute. The highest yields occur along the Grand, Chariton, Nodaway, and Lower Platte Rivers. Favorable areas in the glacial drift are indicated by presence of sand and gravel deposits which are free of silt and clay. The greater the thickness of the glacial drift the higher the potential yield. Glacial drift sands of 10 to 100 feet in thickness are capable of yields of 2 to 30 gallons per minute. A few areas having sand thickness greater than 100 feet are capable of yields of 30 to 500 gallons per minute and occasionally up to 1,000 gallons per minute. In addition to poor water quality, yields from bedrock aquifers are too low for most uses.

Water Use

The largest use of water in northwest Missouri is for cooling purposes by electric power plants. These plants pump water either from the Missouri River or from impoundments, such as Thomas Hill Reservoir. Most of the water is returned to the source after use.

Public supplies account for the second most important use of water in the area. The average per capita use of towns with greater than 1,000 population is about 100 gallons per day. The higher per capita use indicated for some towns reflects the use of water by industries. Other important uses include dilution of sewage wastes, livestock watering, farmstead consumption and use, and irrigation.

The source and available supply of water was inventoried for 120 water supply systems in the Missouri portion of the basin. Sources of systems identified in this inventory were streams, wells and lakes (Map 10).



LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- BASIN BOUNDARY
- WELLS
- STREAMS
- LAKES

MAP 10

WATER SUPPLY SOURCE MAP
MISSOURI

NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA

Irrigation is a recent development in the basin and, at present, is primarily supplemental. In 1977, 21,400 acres were irrigated in the Missouri portion of the basin. To date, ground water is the primary source of irrigation water.

Rainfall and runoff are not uniform throughout the year. Seasonal variations in quantity and quality of stream flows occur. Base flows in streams are frequently low. A typical stream has steep banks and murky waters. The average stream gradient is between 2 and 4 feet per mile.

Piecemeal channelization, primarily by landowner groups through drainage associations, has contributed steep banks and straight channels (Map 11). In 1977, the Missouri Department of Conservation completed a stream mileage inventory of the Missouri portion of the basin. All named and unnamed streams were measured from topographic maps, except for first order streams and their tributaries. The Missouri portion of the basin was once drained by 10,367 miles of streams, but channelization has decreased stream mileage to 9,667 miles, a loss of 700 miles.

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LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- COUNTY SEATS & TOWNS OVER 15,000
- DRAINAGE
- LAKES
- INTERSTATE HIGHWAY
- U.S. HIGHWAY
- BASIN BOUNDARY
- CHANNELED DRAINAGE

MAP 11

1977
STREAM CHANNELIZATION
NORTHERN MISSOURI RIVER TRIBUTARIES BASIN
MISSOURI AND IOWA

SOURCE
FAMILY OF MAPS SCS DRWG. NO. S,R-35,055 (3-78), AND INFORMATION FROM FIELD TECHNICIANS
LAMBERT CONFORMAL CONIC PROJECTION

3-30-78
S,S- 36,927

(C) COUNTY SEATS

Streams of the basin add diversity to the landscape. The water, plus associated streambank cover, is important to many wildlife species. Stream fishes includes many species of minnows, several species of shiners, bullheads, carp, channel catfish, flathead catfish, carpsuckers, and buffalo. Many river oxbows contain drum, gizzard shad, buffalo, carpsucker, and gar.

Ponds and lakes in the basin are among the most productive in Missouri. Typical pond and lake fish are minnows, bluegills, bullhead, channel catfish, carp, largemouth bass, white bass, black crappie, white crappie, and green sunfish. Tiger muskie, northern pike, and redear sunfish have been established in some public lake environments.

F. Outdoor Recreation (Missouri)

Most of the land adjacent to streams is privately owned. Although the Missouri Department of Conservation has developed a number of stream access points, they receive minimal use. Hiking, camping, picnicking, and canoeing are activities most suitable to the basin's streams. The most favorable stream reaches for these activities are the Upper Chariton, Middle to Lower Locust, Upper Thompson, Lower Weldon, Middle Big Creek, East Fork of the Grand, Grand River, Shoal Creek, Middle and Lower Platte, and the Lower Nodaway. Canoeing is most favorable during high flows.

The recreation work group identified 25 outdoor recreational activities and ranked them according to activity occasions (Table 8). These activities are both water based and land based with the latter capturing the most interest. Of the most popular 10 activities polled, only two were water based: swimming in pools and warm water fishing.

The 1976 State Comprehensive Outdoor Recreation Plan report identifies five activities involved with lake usage. These are warm water fishing, swimming, boating, water skiing, and sailing. During 1975, there were 1,677,700 activity occasions centered on lake usage, 7 percent of all activity occasions.

Playing games was the most important activity with 5,181,800 activity occasions in 1975. Other top activities and their activity occasions include bicycling (4,459,000), driving the family auto (3,537,000), urban walking (2,085,800), and swimming in pools (1,487,900).

Five recreational regions overlap the basin (Map 12). The 1976 SCORP identifies over 52,000 acres of boating water and almost 57,000 acres of fishing water in the 5-region area (Table 9). Relatively few facilities are developed in view of the acreage of available water; only 170 acres are suitable for skiing, and only 56 launching ramp lanes are in use (Table 10).

G. Fish And Wildlife

Game animals and birds; such as deer, turkeys, prairie chickens, quail and some elk; were very abundant when the settlers arrived. Also a great many wolves, raccoons, squirrels, and a few panthers were present.

Settlement brought about changes in land use and wildlife populations. Many of the prairie birds and mammals were displaced as prairie acres declined.

Table 8 -- Missouri Recreational Demand, as Activity Occasions; 1975. Northern Missouri River Tributaries Basin. (1976 SCORP, Missouri DNR)

	Activity	Thousand Activity Occasions
1.	Playing Outdoor Games	5,181.8
2.	Bicycling	4,459.0
3.	Driving Family Auto	3,537.1
4.	Urban Walking	2,085.8
5.	Swimming, Pools	1,487.9
6.	Viewing Outdoor Games	1,486.3
7.	Bird Watching	1,279.3
8.	Sightseeing	837.6
9.	Picnicking	794.7
10.	Fishing, Warm Water	668.6
11.	Nature, Walking	547.6
12.	Swimming, Lakes	483.5
13.	Horseback Riding	385.7
14.	Boating, Motorized	376.6
15.	Hunting, Small Game	201.4
16.	Motorized Camping	190.6
17.	Tent Camping	116.1
18.	Water Skiing	113.0
19.	Hiking, With Gear	80.0
20.	Canoeing, Floating	41.1
21.	Organized Camping	38.0
22.	Sailing	36.0
23.	Water Fowl Hunting	30.7
24.	Hunting, Big Game	24.7
25.	Bow & Arrow Hunting	9.1
	TOTAL	24,492.2

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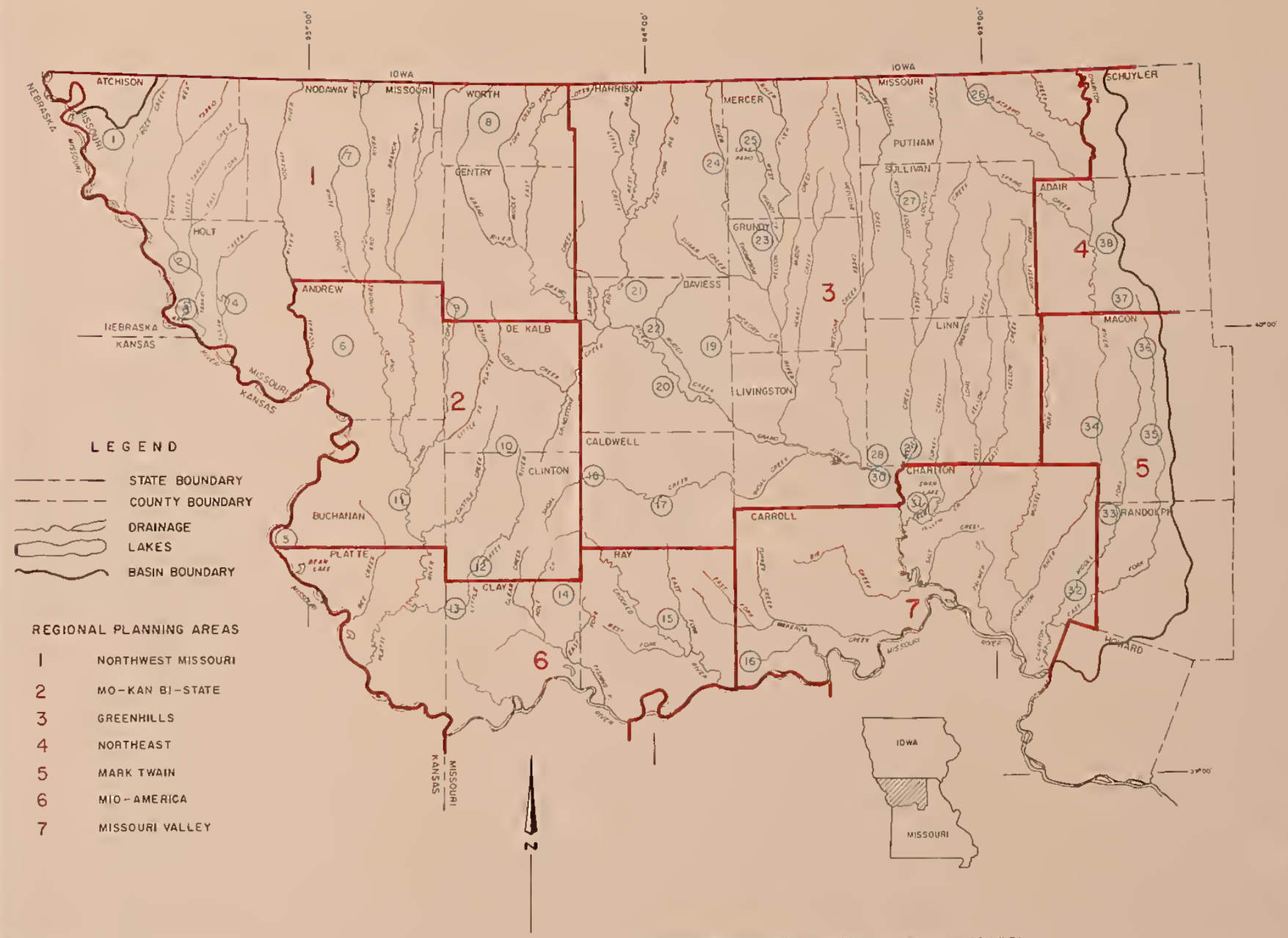


RECREATIONAL AREAS

			ACREAGE
1	BRICKYARD HILL WILDLIFE AREA		1,476
2	THURNAU WILDLIFE AREA		366
3	BIG LAKE STATE PARK		111
4	SQUAW CREEK NATIONAL WILDLIFE REFUGE		6,867
5	LEWIS AND CLARK STATE PARK		35
6	HONEY CREEK WILDLIFE AREA		1,448
7	NODAWAY LAKE		320
8	WORTH COUNTY COMMUNITY LAKE		20
9	LIMPP COMMUNITY LAKE		29
10	PONY EXPRESS WILDLIFE AREA		1,862
		WATER	240
11	PIGEON HILL WILDLIFE AREA		336
12	TRIMBLE WILDLIFE AREA		1,197
		WATER	160
13	SMITHVILLE RESERVOIR		12,180
14	WATKINS MILL STATE PARK		1,299
15	RAY COUNTY COMMUNITY LAKE		25
16	SCHIFFERDECKER MEMORIAL WILDLIFE AREA		240
17	BONANZA WILDLIFE AREA		1,024
18	WALLACE STATE PARK		422
19	JAMESPORT COMMUNITY LAKE		30
20	GALLATIN WILDLIFE AREA		570
21	LOUISBURG TRACT		160
22	LAKE VIKING		542
23	CROWDER STATE PARK		674
24	HELTON WILDLIFE AREA		1,343
25	LAKE PAHO WILDLIFE AREA		754
		WATER	273
26	LAKE THUNDERHEAD		1,200
27	SEARS COMMUNITY LAKE		19
28	JO SHELBY LAKE		30
29	PERSHING STATE PARK		1,836
30	FOUNTAIN GROVE WILDLIFE AREA		5,451
		WATER	2,150
31	SWAN LAKE NATIONAL REFUGE		10,977
		WATER	4,950
32	STERLING PRICE COMMUNITY LAKE		35
33	THOMAS HILL RESERVOIR LANDS		10,500
34	GRIFFIN MEMORIAL WILDLIFE AREA		128
35	LONG BRANCH RESERVOIR		2,430
36	ATLANTA WILDLIFE AREA		2,044
37	SUGAR CREEK STATE FOREST		936
38	THOUSAND HILLS STATE PARK		3,192

MAP 12

RECREATIONAL REGIONS AND AREAS MAP

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

IOWA AND MISSOURI

SOURCE:
FAMILY OF MAPS S.C.S. DRWG NO 5,R-35,055 (6-78), AND INFORMATION FROM FIELD TECHNICIANS.
LAMBERT CONFORMAL CONIC PROJECTION

REV. 8-22-79
5,P-37,146

Table 9 -- Missouri Water Acreage by Region, Northern Missouri River Tributaries Basin. (1976 SCORP, Missouri DNR)

Region	Boating Acres	Fishing Acres	Total
	- - - - - - - - - - -1000 acres- - - - - - - - - -		
Northwest Missouri	11.7	11.9	23.6
Mo-Kan Bi-State	4.4	5.3	9.7
Green Hills	5.9	7.1	13.0
Mid-America	14.4	14.7	29.1
Missouri Valley	16.3	17.6	33.9
TOTAL	52.7	56.6	109.3

Table 10 — Public Water Facilities, by Region; Northern Missouri River Tributaries Basin. (1976 SCORP, Missouri DNR)

Region	Northwest Missouri	Mo-Kan Bi-State	Green Hills	Mid America	Missouri Valley	Total
Boating (Acres)	11,705	4,415	5,898	14,405	16,300	52,723
Access Ramps (Lanes)	3	8	15	24	6	56
Skiing (Acres)	0	0	170	0	0	170
Swimming Pools (Sq. Ft.)	48,192	51,250	58,000	89,470	12,500	259,462
Beach Area (Sq. Ft.-100)	10	43,790	5,149	1,870	228	51,047
Fishing (Acres)	11,918	5,282	7,141	14,675	17,603	56,619

Farm game wildlife and the songbirds adapted to agricultural land uses increased in numbers. Uncontrolled hunting and lack of habitat management led to the over harvest and the decline of many species, especially deer and turkey.

Presently rabbit, squirrel, quail, dove, pheasant, raccoon, and coyote all have fairly stable populations. Deer and turkey populations have been growing steadily under modern game management; also many nongame species are found throughout the basin.

The highest game populations are found in areas of diverse land cover and small fields, typically in the "breaks" where broad flats give way to river valleys. The areas of good habitat remain where intensive agricultural practices are difficult to carry out; usually in these "breaks".

The western one-third of the basin in Missouri had low wildlife habitat values in 1939-40 and still had low values in 1978. Generally, the remainder of the basin had very good habitat values in 1939-40. These very good habitat values decreased by 1978, but still provide good wildlife habitat. Existing wildlife habitat still appears to support a good population of game species, as witnessed by harvest records. The basin's percentage of total state harvest has recently remained fairly constant (Table 11).

Table 11 -- Harvest Data for Northwest Prairie and Northern Riverbreaks Zoogeographic Regions in Missouri by Selected Years, Northern Missouri River Tributaries Basin.

Small Game	Percent of Total State Harvest			Basin Harvest		
	(1969)	(1973)	(1977)	(1969)	(1973)	(1977)
Rabbit	15	12	15	308,546	250,708	304,001
Squirrel	6	6	11	156,756	191,446	268,532
Quail	21	23	24	637,588	814,247	653,713
Dove	18	13	13	152,533	181,499	219,970
Pheasant	90	94	92	9,793	16,706	14,172
Woodcock	*	9	11	*	1,403	1,731
Forest Game	(1966)	(1971)	(1977)	(1966)	(1971)	(1977)
White-Tailed Deer	14	11	19	3,713	3,588	7,194
Turkey	**	5	9	**	147	879
Furbearers	(1968)	(1971)	(1977)	(1968)	(1971)	(1977)
Raccoon	19	16	16	20,388	19,664	40,002
Opossum	3	3	7	570	899	5,983
Muskrat	20	20	12	12,505	14,632	10,016
Coyote	36	38	35	149	1,125	8,604
Gray Fox	3	3	2	30	52	244
Red Fox	13	13	14	140	208	589
Beaver	24	12	19	711	263	1,122
Bobcat	3	1	1	1	1	16
Spotted Skunk	17	10	5	16	8	8
Waterfowl	(1969)	(1973)	(1977)	(1969)	(1973)	(1977)
Ducks	25	27	23	40,061	110,475	93,958
Geese	50	83	72	66,572	57,735	66,825

* No harvest data available ** No open season in basin

H. Wetlands

A 1955 wetland inventory identified 62,606 acres, or 28 percent of all Missouri wetlands, in the basin. The 1977 inventory found only 35,423 acres of wetlands (Map 13). Five counties along the Missouri River; Buchanan, Chariton, Holt, Platte, and Ray; and three along the Grand River; Daviess, Linn, and Livingston; account for 92 percent of the basin wetlands.

The basin's wetlands support a great variety of plant and animal life. Wetlands add diversity to the landscape, serve as flood storage basins, are areas of natural beauty, and provide ground water recharge areas. They have particular value in production, migration, and wintering habitat for many fish and wildlife species; particularly waterfowl, shorebirds, and furbearers.

Missouri is located within the Mississippi Flyway. This waterfowl and shorebird migration route is one of the four main routes across the United States. The northwestern portion of the state occupies an important location to this flyway. This was recognized when two National Wildlife Refuges, Squaw Creek near Mound City and Swan Lake near Sumner, Missouri, were developed in this area. These refuges are managed primarily to benefit waterfowl and shorebirds. The state also has an area near Swan Lake, the Fountain Grove Wildlife Area, managed for marsh conditions.

Squaw Creek (6,887 acres), established in 1935, is a stopping place for migrating ducks and geese, especially snow and blue geese, canada geese, and mallards. Goose populations frequently reach 300,000 during spring migrations. The area is popular with bird watchers and other wildlife observers.

Swan Lake (10,700 acres), at the junction of the Yellow and Grand Rivers, serves as a major resting and feeding area for one of the largest single concentrations of canada geese in North America, at times exceeding 100,000 birds. Controlled public goose hunting is permitted on the refuge under the administration of the Missouri Department of Conservation. Spectacular goose and duck concentrations and public fishing and hunting are major attributes of Swan Lake National Wildlife Refuge, established in 1937.

These areas are an important component in maintaining populations of waterfowl in the Mississippi Flyway. They also serve as a major economic boost to the local communities from income generated from hunting leases, equipment purchases, etc.

I. Archeological And Historical Resources

The history of the region is divided into nine cultural periods. The prehistoric periods are grouped into six cultural traditions. This information is summarized in Table 12.

U. S. DEPARTMENT OF AGRICULTURE

LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- COUNTY SEATS & TOWNS OVER 15,000
- DRAINAGE
- LAKES
- INTERSTATE HIGHWAY
- U.S. HIGHWAY
- BASIN BOUNDARY
- WETLAND LOCATIONS

MAP 13

WETLANDS

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

MISSOURI

SOURCE
FAMILY OF MAPS S C S DRWG NO 5,R-35,055 (6-78),
AND INFORMATION FROM FIELD TECHNICIANS
LAMBERT CONFORMAL CONIC PROJECTION
USDA-SCS-LINCOLN, NEBR 1982

SCALE 0 10 20 30 40 50 MILES
0 10 20 30 40 50 60 70 80 KILOMETERS

7-17-78
5,P-36,980

Table 12 -- Chronological Sequence, Northwest Prairie Region Northern Missouri River Tributaries Basin, Missouri*

Cultural Traditions	Cultural Periods	Date
	Historic	A.D. 1700
Village Farmer	Mississippi	A.D. 900
Prairie-Forest Potter	Woodland	1000 B.C.
	Late Archaic	3000 B.C.
Forager	Middle Archaic	5000 B.C.
	Early Archaic	7000 B.C.
Hunter-Forager	Dalton	8000 B.C.
Early Hunter	Paleo-Indian	12,000 B.C.
Unspecialized Hunter-Gatherer	Early Man	?

*Modified from Archaeology of Missouri, I, Carl H. Chapman, University of Missouri Press, Columbia, Missouri, 1975.

The Iowa State Archeologist lists 548 historical and archeological sites in the Iowa counties included in the basin. The Missouri Department of Natural Resources lists 2,151 historical and archeological sites in the Missouri counties included in the basin. The state records have been compiled from professional surveys and reports by amateurs. Only very limited areas of the basin have been surveyed. As a result, the known sites are believed to represent only a small sample of the potential resources.

The National Register of Historic Places (NRHP) was consulted for properties in the basin. The Register contained 33 sites and six sites were under consideration for nomination.

The existing archeological information demonstrates that at least four cultural traditions are present. Those identified include Unspecialized Hunter-Gatherer, Early Hunter, Hunter-Forager, and Forager. Most of the known archeological resources have been found in the alluvial areas associated with streams or the wooded upland areas adjacent to them.

The area contains many historic resources. A review of those historic properties on the NRHP shows that the majority are associated with towns. Most are courthouses, railroad depots, homes of famous persons, and churches. One of the better known properties is the Pony Express stables in Buchanan County.

J. Unique, Scenic, And Natural Areas

Natural areas serve as examples of conditions as they originally existed in Missouri. They are defined as biological communities, either terrestrial or aquatic, in a natural or nearly undisturbed state. Natural areas are often thought of as scenic, and certainly many of them are. The integrity of any undisturbed natural area gives it a character that has beauty to the perceptive observer. The principal native vegetative cover of the basin was prairie grass (Map 14).

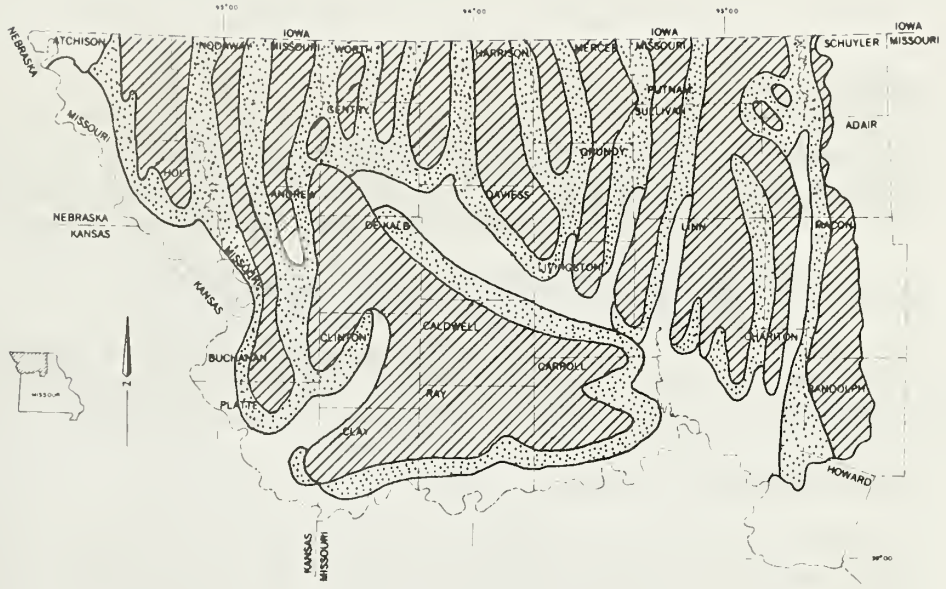
There is a growing interest in natural areas. In April 1977, the Missouri Department of Conservation and the Missouri Department of Natural Resources entered into a cooperative agreement for coordination of a state natural areas program. Under the agreement, each agency is represented by four members on a Missouri Natural Areas Committee. This committee administers a broadly based statewide natural areas program.

Several inventories of natural areas have been conducted in various locations (Map 15). The following summarizes the available information. Nine counties; Clay, Macon, Randolph, Ray, De Kalb, Clinton, Platte, Buchanan, and Andrew; have had natural area surveys conducted as a part of Regional Planning District Reports. An undated list of "Areas in Need of Protection" was developed by Julian Steyermark, author of Flora of Missouri. Locations on this list are in need of verification. Steyermark identified "Areas in Need of Protection" in Howard, Schuyler, Sullivan, Mercer, Harrison, and Holt counties.

There are four official Missouri Natural Areas in the basin. These are Brickyard Hill Loess Mounds, Atchison County; Jamerson C. McCormack Natural Area, Holt County; Maple Woods Nature Preserve, Clay County; and Hidden Valley Natural Area, Clay County. One heron rookery has been identified in Linn County. The Missouri Department of Conservation is aware of three additional natural areas in Atchison, Nodaway, and Holt Counties.

A natural area survey being conducted by the Missouri Department of Natural Resources is in progress within the basin area. The results from this study will, no doubt, increase the number of areas identified.

The following descriptions are of existing natural areas which have potential for official designation. For some of these areas, legal descriptions may be obtained from the Missouri Natural Areas Committee.



LEGEND

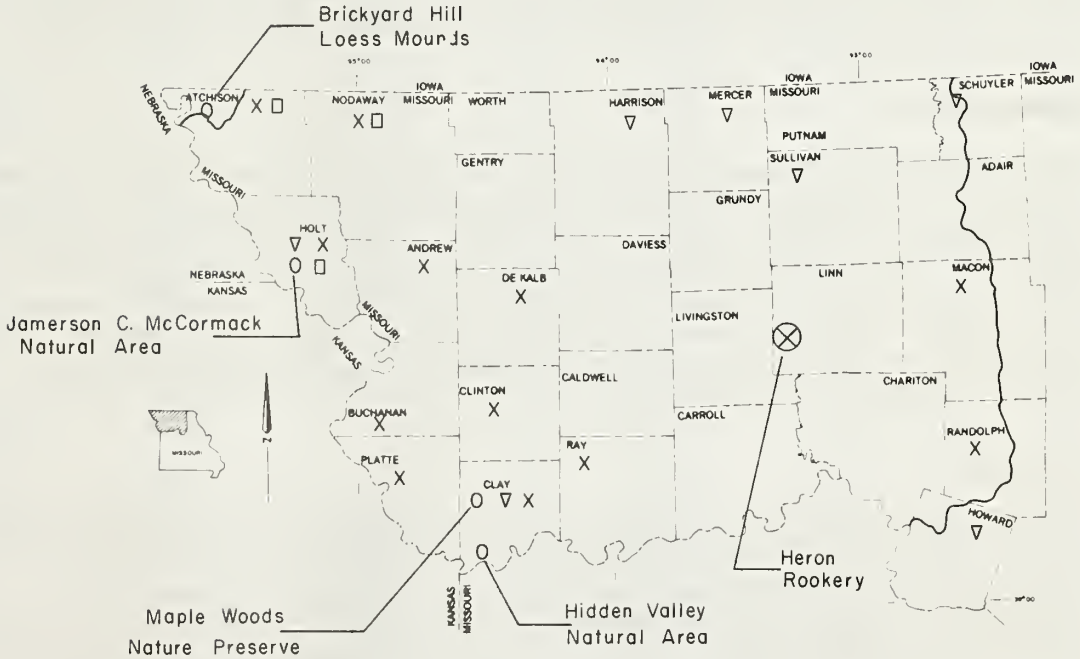
- STATE BOUNDARY
- COUNTY BOUNDARY
- BASIN BOUNDARY
- PRAIRIE
- UPLAND FOREST
- BOTTOMLAND FOREST

MAP 14

PRESETTLEMENT VEGETATION
MISSOURI

NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA

FROM: The Grasses of Missouri, Kucera,
University of Missouri 1961



LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- BASIN BOUNDARY
- O OFFICIAL MISSOURI NATURAL AREA
- X COUNTIES WITH NATURAL AREA SURVEYS
- ▽ COUNTIES IN WHICH STEYERMARK IDENTIFIED A SIGNIFICANT AREA
- □ COUNTIES WITH NATURAL AREA IDENTIFIED BY OTHER SOURCES

MAP 15

NATURAL AREAS
MISSOURI

NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA

Atchison County, Missouri

An excellent 10-acre to 13-acre tall grass prairie is located on a northwest facing ridge five miles west of Elmo, Missouri. It includes three main grassland communities, prairie cordgrass, big bluestem, and porcupine grass.

Clinton County, Missouri

Two areas have been suggested for designation; one is located near the Little Platte River and the other along Castile Creek. The principal features of both areas are the unusual number of orchids (Aplectrum hye male/f. hyemale).

Nodaway County, Missouri

The Nature Conservancy, a private organization active in natural areas preservation, owns two tracts within the basin study area. Dobbins Woodland, a 40-acre tract in Nodaway County, is an oak-hickory forest traversed by two streams and is a refuge for over 100 species of birds.

Holt County, Missouri

The second tract owned by the Nature Conservancy is an oak-hickory forest on the Missouri River hills situated on deep, loess mounds in Holt County.

Daviess County, Missouri

A section along Marrowbone Creek in Daviess County is also under consideration for nomination to the Natural Areas Committee. The area is described as one of the best remaining examples of upland forest in the glaciated regions of northern Missouri.

K. Economic Base

Present economy of the basin is a result of the development of natural resources, as tempered by institutions. The future economy will be influenced by historical trends, but the direction and extent of changes will be modified by influences outside the basin and the desires of people in the basin. For example, the current energy shortage may result in increased coal mining in the basin for energy in other areas. Past trends and future projections of changes in population and employment are analyzed to provide a basis for considering the needs for water and land resource development.

Population

The basin is typical of many midwestern agricultural areas with numerous small towns and villages. The rural nature of the area is depicted by the population density, which was 39 persons per square mile in 1980. By comparison, the average density for the State of Missouri was 71 persons per square mile. About 506,000 people resided in the Missouri portion of the basin in 1980. Although the area comprises 19 percent of the state, only 10 percent of the state's population resides there.

The largest city is St. Joseph with a population of 76,691 in 1980 (Table 14). The second largest city is Gladstone with a population of 24,990. Only three

Table 14 -- Population of Principal Communities 1950-1980 (Population of 2,000 or More in 1970), Northern Missouri River Tributaries Basin, Iowa and Missouri (Source: U.S. Census of Population)

City	County	Population				Population Increase Index, 1950 = 100		
		1950	1960	1970	1980	1960	1970	1980
(Iowa)								
Atlantic	Cass	6,480	6,890	7,306	7,789	106.3	112.7	120.2
Audubon	Audubon	2,808	2,928	2,907	2,841	104.3	103.5	101.2
Bloomfield	Davis	2,688	2,771	2,718	2,849	103.1	101.1	106.0
Centerville	Appanoose	7,625	6,629	6,531	6,558	86.9	85.6	86.0
Clarinda	Page	5,086	5,901	5,420	5,458	116.0	106.6	107.7
Creston	Union	8,317	7,667	8,234	8,429	92.2	99.0	101.3
Glenwood	Mills	4,664	4,783	4,195	5,280	102.5	89.9	113.2
Harlan	Shelby	3,915	4,350	5,049	5,357	111.1	129.0	136.8
Lamoni	Decatur	2,196	2,173	2,540	2,705	98.9	115.7	123.2
Red Oak	Montgomery	6,526	6,421	6,210	6,810	98.4	95.2	104.3
Shenandoah	Page	6,938	6,576	5,968	6,274	94.6	86.0	90.4
(Missouri)								
Bethany	Harrison	2,714	2,771	2,914	3,095	102.1	107.4	114.0
Brookfield	Linn	5,810	5,694	5,491	5,555	98.0	94.5	95.6
Cameron	Clinton	3,446	3,480	3,469	3,829	101.0	100.7	111.1
Carrollton	Carroll	4,380	4,554	4,847	4,700	104.0	110.7	107.3
Chillicothe	Livingston	8,694	9,236	9,519	9,089	106.2	109.5	104.5
Excelsior Springs	Clay	5,852	6,418	10,294	10,288	109.7	175.9	175.5
Gladstone	Clay	-	14,502	23,128	24,990	-	-	-
Kirksville*	Adair	11,100	13,123	15,560	17,167	118.2	140.2	154.6
Liberty	Clay	4,709	8,909	13,679	16,251	189.2	290.5	345.1
Macon*	Macon	4,152	4,547	5,301	5,680	109.5	127.7	136.8
Marceline	Linn	3,172	2,872	2,622	2,938	90.5	82.7	92.6
Maryville	Nodaway	6,834	7,807	9,970	9,558	114.2	145.9	139.9
Moberly	Randolph	13,115	13,170	12,988	13,418	100.4	99.0	102.3
N. Kansas City	Clay	3,886	5,657	5,183	4,507	145.6	133.4	116.0
Platte City	Platte	742	1,188	2,022	2,114	160.1	272.5	284.9
Richmond	Ray	4,299	4,604	4,948	5,499	107.1	115.1	127.9
Riverside	Platte	-	1,315	2,123	3,206	-	-	-
Savannah	Andrew	2,332	2,455	3,324	4,184	105.3	142.5	179.4
St. Joseph	Buchanan	78,588	79,673	72,691	76,691	101.4	92.5	97.6
Tarkio	Atchison	2,221	2,160	2,517	2,375	97.3	113.3	106.9
Trenton	Grundy	6,157	6,262	6,063	6,811	101.7	98.5	110.6
Unionville	Putnam	2,050	1,896	2,075	2,178	92.5	101.2	106.2

* County seats just outside basin boundary.

other towns, Liberty, Moberly, and Excelsior Springs have populations over 10,000. The remaining 205 towns have populations of fewer than 10,000 people; and 90 percent are smaller than 2,000. In 1980, 58 percent of the people resided in towns or villages and 42 percent lived in the country.

Inspection of growth rates for the 24 Missouri counties, designated as representative of the basin area, indicated population trends for all but two counties were similar. Because of their proximity to Kansas City, the population of Clay and Platte Counties has increased steadily since 1940. These two counties with a population of 182,800 in 1980 were therefore analyzed separately. Only 323,400 people resided in the 22 counties, resulting in a population density of 27 per square mile compared to 218 per square mile for Platte and Clay Counties.

Population in the 22-county area decreased rapidly from 1940 to 1960, from 403,843 to 327,887 (Figure 5). The rate of loss slowed after 1960, but by 1970 population had declined to 312,793. Since 1970, the trend reversed and population had increased slightly to 323,400 by 1980. Population is expected to remain fairly stable with only a slight increase by 1990, according to projections made by the State of Missouri. If this trend continues, population would increase only slightly, to 331,500 by year 2020.

The southwestern part of the basin, adjacent to Kansas City, is expected to continue to increase in population at a rapid rate. Clay and Platte Counties were selected as representative of this area, but these projections may also apply to parts of Ray and Buchanan Counties.

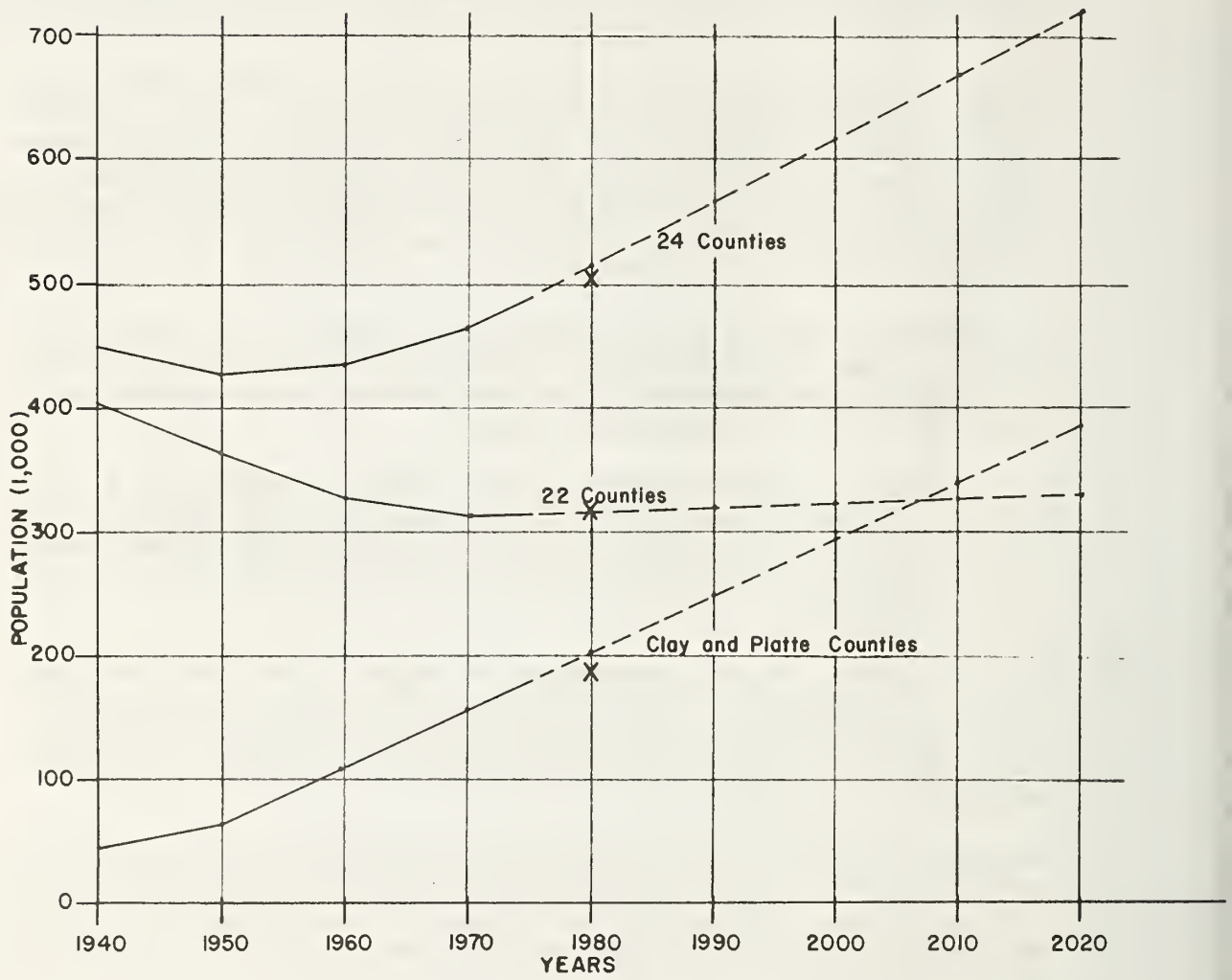
The combined population of Clay and Platte Counties increased from 44,279 in 1940 to 182,822 in 1980. State projections indicate this growth rate is expected to continue through 1990, resulting in a population of 241,500. Continuation of this trend through 2020 would result in a population of 386,000 for these two counties.

One of the specific needs for population projections in River Basin planning is to provide guidelines of needs for future water for towns. Year 1940 was used to establish the size class category of each town in the 22-county area and to indicate the trends for the total population of all towns in a given size category since 1940 (Figure 6).

With the exception of the over 10,000 size category, the trends have been consistent since 1940. In general, the smaller towns have lost population, and towns with population of 2,000 or more have gained. These projections are provided as guidelines only and should be tempered by local considerations when planning for specific towns.

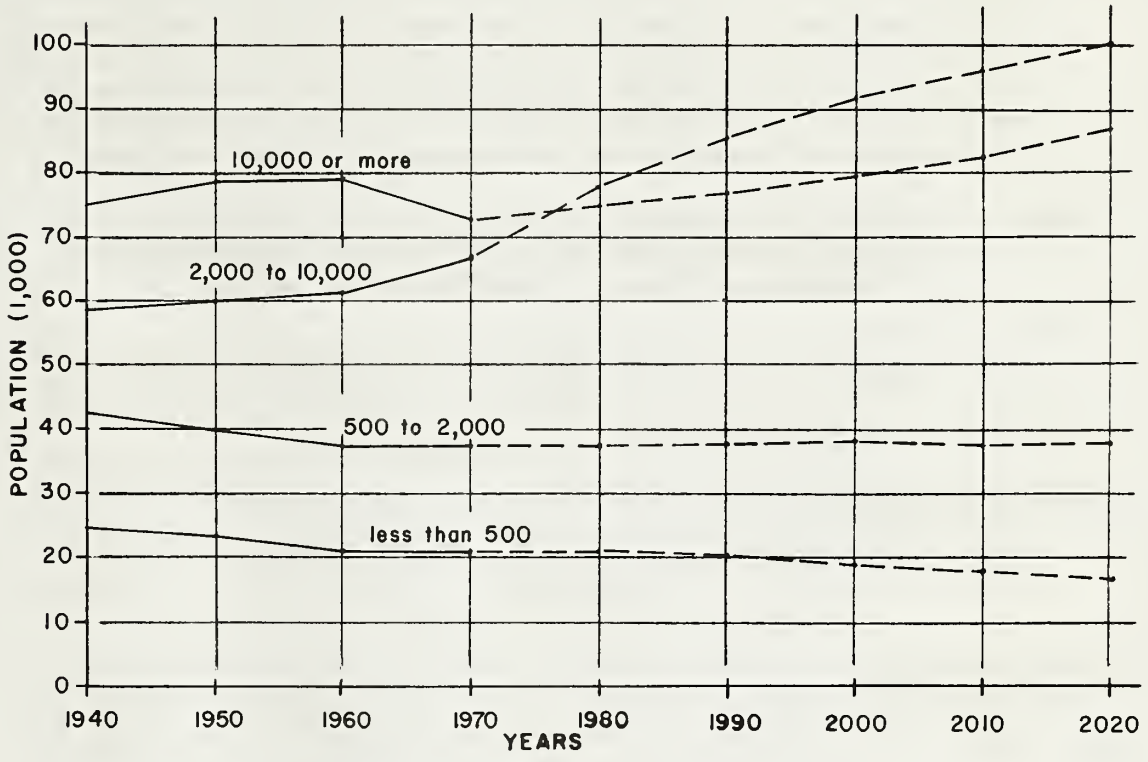
Baseline population projections are based on the assumption that there will be no unusual or unforeseen changes in the underlying economic forces in the basin. Their basic purpose is to provide a baseline for evaluation of resource use. A change in resource use, such as extensive development of the coal resources in the basin, would result in different population projections. The difference in baseline "with" coal development would indicate one impact of resource development.

Figure 5 -- Total Population Trends and Projections for Representative Missour Counties, Northern Missouri River Tributaries Basin. (Source: U.S. Census of Population; OBERS Projections, Vol. 1, U.S. Water Resources Council, Washington, D. C., 1972; Missouri Population Estimates and Projections, College of Business and Public Administration, University of Missouri, Columbia, Missouri, July 1965)



X - ACTUAL

Figure 6 — Population Trends and Projections by Town Size Groups for Representative Missouri Counties, Northern Missouri River Tributaries Basin. (Source: U.S. Census of Population, OBERS Projections, Vol. 1, U.S. Water Resources Council, Washington, D.C., 1972; Missouri Population Estimates and Projections, College of Business and Public Administration, University of Missouri, Columbia, Missouri, July 1965)



Several implications can be made from these baseline projections. Resource development for purposes directly related to local population need not expand much beyond present needs in most areas of the basin. The exception to this is the area adjacent to Kansas City. Since no great influx of people is expected into the area, the local demand for water quality, water supply, local recreation, and wildlife will probably not expand much beyond the present demand. Rather, the major demand for resource use and development will probably come from outside the basin. The demand from outside the basin for agricultural products, energy, recreation, wildlife, and cleaner water will be major forces shaping resource use in the future.

Employment and Income Base and Projections

The economic base of an area is an important factor in determining its growth or decline. Historically, agriculture was the basic industry of the basin. The rapid change in technology in this sector has resulted in a decline in agricultural employment which has not been fully offset by a corresponding increase in employment in other sectors.

Income levels in the 22-county area representing the majority of the basin are below average state levels for both rural farm and rural nonfarm population (Table 15). The mean annual income for families in the 22-county area was $8,230, compared to $12,139 for the two counties adjacent to Kansas City and $10,236 for the state. Per capita incomes are correspondingly lower in the rural area. About 14.9 percent of the families in the 22-county area had incomes below what was considered poverty level in 1970, this compares to 11.5 percent for the state and 4.2 percent for the two counties adjacent to Kansas City.

Table 15 -- 1970 Missouri Family Income Comparison, Rural Farm and Rural Nonfarm, Northern Missouri River Tributaries Basin, (Source: U.S. Census of Population 1970)

Area	Mean Annual Income	Per Capita Annual Income	Families With Less Than Poverty Level*
	- - -Dollars- - -		- -Percent- -
State of Missouri:			
Rural Farm	7,926	2,369	16.7
Rural Nonfarm	8,080	2,338	12.7
Total	10,236	2,964	11.5
22-County Area:			
Rural Farm	7,708	2,417	15.8
Rural Nonfarm	7,633	2,324	16.7
Total	8,230	2,453	13.9
Clay & Platte Counties:			
Rural Farm	11,096	3,376	7.8
Rural Nonfarm	12,551	3,414	6.0
Total	12,139	3,488	4.2

* The poverty level varies by age and composition of the family. The average poverty threshold for nonfarm family of four was $3,745 and for a farm family was $3,195 in 1970.

The distribution of employment by major industries in 1970 is presented in Table 16. Service industry accounts for about a fourth of the employment in the rural counties, as well as the two counties near Kansas City. The major difference in employment distribution between this rural 22-county area and Platte and Clay Counties is the agricultural-forestry and transportation-utility sectors. Agricultural employment accounts for 16 percent of the employment in the rural area but only 2 percent in the two rapidly growing urban counties.

Table 16 -- Missouri Employment by Major Industry for 22 Counties and Platte and Clay Counties, Northern Missouri River Tributaries Basin. (Source: U.S. Census of Population 1970)

Industry	Employment, 1970			
	22 County Area		Platte & Clay Counties	
	Number	Percent	Number	Percent
Services (including government)	30,312	26.1	16,559	25.4
Wholesale and Retail Trade	24,475	21.1	14,952	23.0
Manufacturing	21,979	18.9	14,212	21.8
Agriculture and Forestry	19,189	16.5	1,547	2.4
Transportation and Utilities	7,791	6.7	11,103	17.0
Contract Construction	7,621	7.1	3,402	5.2
Finance, Insurance, Real Estate	4,011	3.4	3,248	5.0
Mining	788	.7	141	.2
TOTAL	116,166	100.0	65,164	100.0

Trends in employment for the 22 counties are similar to trends in many mid-western rural areas. In 1940, agriculture accounted for 43 percent of the employment (Table 17). By 1970, agricultural employment had declined to 16.5 percent of the total and had been surpassed by employment in three other sectors: services, manufacturing, and trade (Figure 7).

It is anticipated agricultural employment will continue to decrease, but not to the same degree as in the past. Employment in other sectors should increase sufficiently so there will be no major changes in the underlying economic forces in the area. A rapid expansion of a particular sector, mining for example, would invalidate these projections.

Transportation

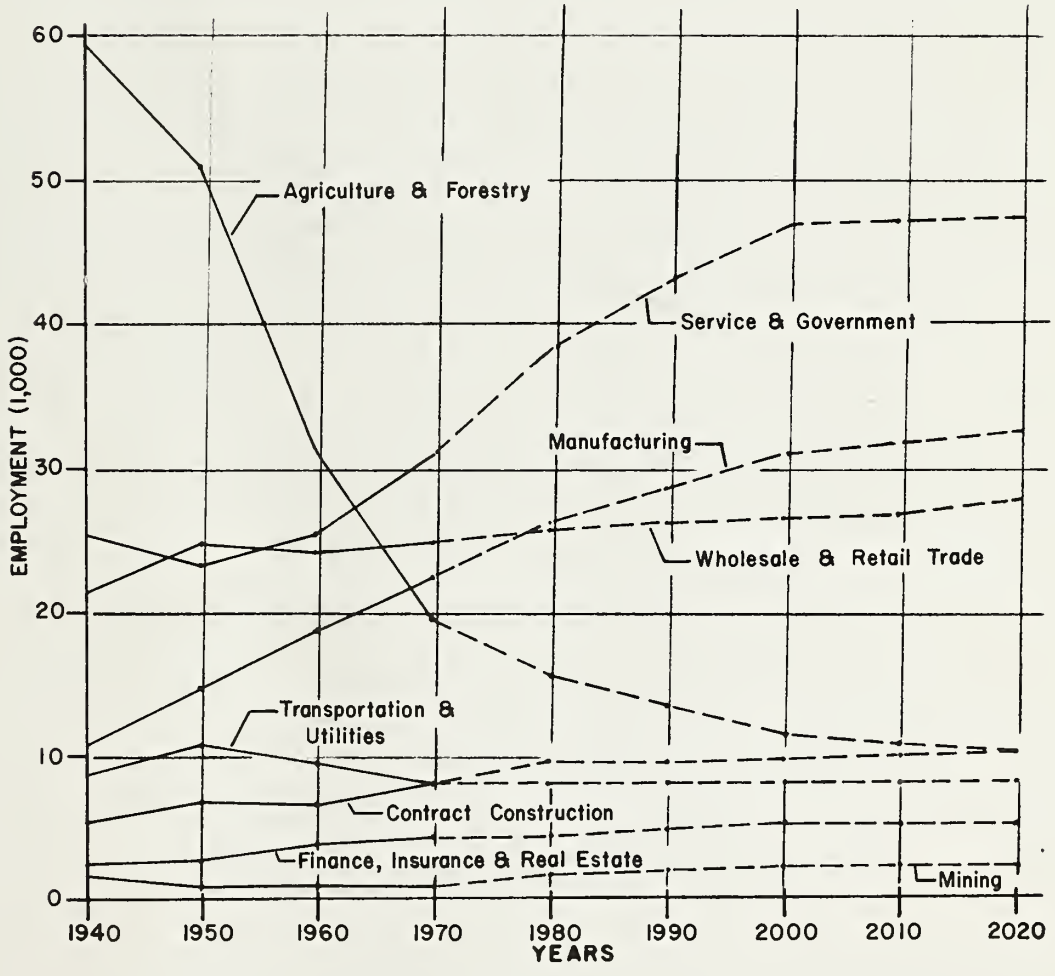
Until the advent of rail and road services, horse and mule drawn freight was the principal mode of transport in the basin. A few adventurous steamers occasionally exchanged goods along the lower Grand River between 1840 and 1870. All counties now have adequate truck and bus facilities. Principal highways traversing the basin north and south are Interstates 35 and 29, and U.S. 59, 71, 169, 69, 65, and 63. Interstate 80, U.S. 6, 24, 136, and 36 are east-west highways. Augmenting these are state hard surface roads and a system of county and township roads, generally with gravel surface. The functional use of some hard surface roads is weakened by obsolete bridges.

Railroads moving freight into and through the basin include the Burlington Northern; Chicago and Northwestern; Chicago, Milwaukee, St. Paul, and Pacific; Atchison, Topeka and Santa Fe; and the Missouri Pacific. The area is served by AMTRAK on the Burlington Northern; Missouri Pacific; and the Atchison, Topeka and Santa Fe. Although a major factor in the development of the basin, the continued deterioration of tracks makes the effectiveness of this transport system questionable in the future.

Table 17 — Missouri Employment Trends and Projection by Major Industry for 22 Representative Counties, Northern Missouri River Tributaries Basin. (Source: U.S. Census of Population; OBERS Projections, Vol. 3, U.S. Water Resources Council, Washington, D. C., 1972)

Item	1940	1950	1960	1970	1980	2000	2020
	----------Number----------						
Population	403,843	365,805	327,887	312,793	317,400	318,800	322,000
Employment	135,886	135,541	120,531	116,166	127,000	137,000	141,000
Employment/Population Ratio	.34	.37	.37	.37	.40	.43	.44
Not reported	1,462	2,545	3,446	-	-	-	-
Agriculture and Forestry	58,770	49,863	30,965	19,189	15,000	11,000	10,000
Mining	1,896	799	544	788	1,600	2,000	2,200
Contract Construction	5,164	6,976	6,406	7,621	9,000	9,300	10,000
Manufacturing	10,826	14,668	18,016	21,979	26,000	30,000	32,000
Transportation and Utilities	8,844	10,605	9,147	7,791	7,800	7,800	8,000
Wholesale & Retail Trade	21,255	24,675	23,453	24,475	25,500	26,000	27,000
Finance, Insurance, Real Estate	2,584	2,670	3,415	4,011	4,500	4,000	5,000
Services (including government)	25,085	22,740	25,139	30,312	37,600	45,900	46,800
Total	135,886	135,541	120,531	116,166	127,000	137,000	141,000
	----------Percent Distribution----------						
Not reported	1.1	1.9	2.9	-	-	-	-
Agriculture and Forestry	43.2	36.8	25.7	16.5	11.8	8.0	7.1
Mining	1.4	.6	.5	.7	11.3	1.5	1.6
Contract Construction	3.8	5.1	5.3	6.6	7.1	6.8	7.1
Manufacturing	8.0	10.8	14.9	18.9	20.5	21.9	22.7
Transportation and Utilities	6.5	7.8	7.6	6.7	6.1	5.7	5.7
Wholesale & Retail Trade	15.6	18.2	19.5	21.1	20.1	19.0	19.1
Finance, Insurance, Real Estate	1.9	2.0	2.8	3.4	3.5	3.6	3.5
Services (including government)	18.5	16.8	20.8	26.1	29.6	33.5	33.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Figure 7 — Missouri Employment Trends and Projections by Major Industry for 22 Representative Counties, Northern Missouri River Tributaries Basin. (Source: U.S. Census of Population; OBERS Projections, Vol. 3, U.S. Water Resources Council, Washington, D. C., 1972)



The Missouri River flowing along the southern and western border of the basin serves as an export system for the basin, with river access for barges at Omaha, Nebraska, St. Joseph, Kansas City, Waverly, Brunswick, and Glasgow, Missouri.

CHAPTER II

PROBLEMS AND CONCERNS

II. PROBLEMS AND CONCERNS

The evaluation of resource problems and needs is basic to developing a basin plan. Public meetings were held so concerns of the local people could be expressed. The State of Missouri agencies were represented at these meetings.

A Plan of Work was developed around 11 concerns: Agricultural Land, Erosion, Pollution, Energy, Wetlands, Wildlife, Water Supply, Irrigation, Flooding, Missouri River Bottoms, and Recreation. In Missouri, state and federal personnel were assigned to work groups (committees). The State of Iowa limited active participation to the flooding work group. The Plan of Work was approved by the local public and participating state and federal agencies. Iowa prepared a separate Plan of Work for the Southern Iowa River Basin Report.

Problems and concerns were analyzed by each work group and documented in Inventory and Analysis Reports. Where feasible, problems and concerns documented by the Southern Iowa River Basin Report are presented in this chapter. Table 18 is a list of identified concerns. The following discussion is arranged by work group concerns. More details can be found in the reports listed in Chapter 1, Section F, available through the Soil Conservation Service, Columbia, Missouri.

A. Agricultural Land

The major resource problems confronting agriculture, which are also of public concern, are erosion, water quality, water supply, and flooding. Each of these problems is discussed in separate major sections of this report. The following discussion will be limited to analyzing these problems within the context of their impact on agriculture.

Production Capacity of the Basin

The capacity of the basin to increase agricultural production from shifts in land use and irrigation was analyzed using a linear programming model as an aid. The model simulated land use shifts, irrigation, costs, income, and erosion. Production increments of 5 percent were used for all products. Increased production was obtained in the model through land use shifts and irrigation. Prices, costs, yields, and technology were held constant. The model indicates the least cost method of increasing production under given conditions.

The analysis indicates that overall production could theoretically be increased about 37 percent through extensive irrigation and land use shifts (Table 19). However, expansion of production would be economically feasible only to the 30 percent level. Beyond that, net income decreases as output is increased.

Production could be increased by 20 percent by shifting about 800,000 acres from forest to pasture or crops and by irrigating 921,000 acres. Net income would increase by 10 percent and erosion would be 32 percent greater. Fuel, labor, and fertilizer inputs would increase by 56, 22, and 20 percent, respectively, and insecticide and herbicide use would rise by 6 percent. Increased fuel consumption would result primarily from projected increases in irrigated acreage.

Table 18 -- 1980 Status and Projected 2000 Status of Resource Concerns in Northern Missouri River Tributaries Basin.

CONCERNS	UNIT	IA	MO	1980 STATUS	2000 STA
Gross Erosion	Av.An.Tons	X	X	100,000,000	Increas
Gross Erosion Rate	Av.An.Tons/Acre	X	X	8.4	Increas
Mo. Upland Cropland Sheet & Rill Erosion Rate	Av.An.Tons/Acre		X	22.0	Increas
Ia. Upland Cropland Sheet & Rill Erosion Rate	Av.An.Tons/Acre	X		16.1	No Char
Sediment Yield to Missouri River	Av.An.Tons	X	X	35,000,000	Increas
Suspended Sediment at Stream Mouths	Parts Per Million		X	2,000 to 11,000	Increas
Stream Miles	Miles		X	9,700	Decreas
Perennial Stream Miles	Miles		X	1,836	Decreas
Wetland Habitat Acres	Acres		X	35,423	Decreas
Wildlife Habitat Diversity Decline	Percent since 1940		X	8	Decreas
Agricultural Flood Plain Flooded	Acres	X	X	1,070,000	Increas
Average Annual Acres Flooded	Acres	X	X	681,500	Increas
Agricultural Flood Damages	Av.An. $	X	X	32,341,300	Increas
Land Affected by Mining	Acres		X	23,000	Increas
Depreciated Prime Land	Acres		X	12,000	Increas
Forest Land Acres	Acres	X	X	1,459,850	Decreas
Poorly Stocked Timber	Percent		X	62	Increas
Forest Grazing	Percent		X	66	Increas

Table 19 -- Missouri Potential Production Capacity and Net Income From Land Use Shifts and Irrigation, Northern Missouri River Tributaries Basin.

Increase in Production	Irrigation	Cleared Forest*	Net Income	Erosion	Fertilizer	Insect & Herbicides	Fuel	Labor
Percent	-------1,000 Acres-----		----------Percent of Baseline----------					
Baseline	21	0	100	100	100	100	100	100
5.0	151	415	104	95	105	101	112	105
10.0	177	525	106	105	112	106	120	112
15.0	389	790	108	118	117	107	133	118
20.0	921	799	110	132	120	106	156	122
25.0	1,399	1,053	111	132	125	105	174	127
30.0	1,996	1,138	112	129	130	101	200	132
35.0	2,253	1,425	111	131	135	103	215	140
36.9	2,352	1,589	105	165	138	120	229	149

* Forest converted to pasture or cropland

More sheet and rill erosion would occur because of more intensive cropping and farming additional lands without application of soil conservation practices. Sheet and rill erosion rates would drop for the first 5 percent increment in production, increase rapidly until production reaches 20 percent, and then stay about the same until the very last increment in production. The amount of erosion remains about the same after production reaches the 20 percent increment because most of the land use shifts occur prior to this level of production. Irrigation is the primary means of expanding production beyond the 25 percent level.

Upland Problems

In general, net returns to agricultural land decreases as the slope increases (Table 20). Consequently, some economic incentive exists for less intensive use of steeper land. Net return data represents the weighted average of all soils in each slope group for the basin area. Since these are averages, the net returns to a crop on a specific soil, within one of these slope groups, may be different than these averages. For example, the average net returns to continuously tilled crops in Slope Group E are positive for the basin area as a whole because the average is heavily weighted by the better soils in this group.

Intensity of cultivation of upland soils varies directly with the average slope of the land. Fifty-one percent of Slope Groups A and B is utilized for tilled crops, 38 percent is in pasture and hay, and only 6 percent is in forests. The steepest slope group (E) is predominately used for pasture and hay production (44 percent) or covered by forest (42 percent). Only 10 percent is used for tilled cropland. Lower average returns to land in crops for Slope Group E partially explains why these soils, with slopes of over 14 percent, are mostly pastured or forested.

Although there is less economic incentive for cultivating the steeper soils, the interplay of other factors is also apparent. If land use decisions were based only on short term economic considerations, a higher proportion of the upland would be expected to be tilled. A simple interpretation of the data indicates many farmers keep upland in pasture and hay production at a substantial loss in current net income. However, the extent to which conservation goals and other factors, such as risk, enter into land use decisions is impossible to ascertain with the information base available.

Bottom Land Problems

Major resource problems associated with agriculture in bottom land areas are flooding and impeded internal drainage. Only 10 percent of the bottom land is without at least one of these problem areas. About two-thirds of the bottom land is subject to flooding and about 70 percent has inadequate drainage (Table 21). Both problems occur simultaneously on 46 percent of the bottom land. Drainage problems are commonly not perceived until flooding is alleviated. Heavy clay bottom land soils like Wabash and Zook are not suited to subsurface drainage. Bedding is one surface drainage practice used on these soils.

Table 20 -- Missouri Land Use, Sheet Erosion and Average Net Returns to Land and Management, for Upland by Slope Groups, Northern Missouri River Tributaries Basin.

Item	Slope Group A&B 0 to 5%	C 5 to 9%	D 9 to 14%	E 14%	Total
	----------Percent----------				
Land Use					
Forest	6	7	18	42	16
Pasture & Hay	38	50	50	44	46
Tilled Crops*	51	37	28	10	33
Other Land	5	7	4	4	5
Total	100	100	100	100	100
	Average Erosion ----------Tons per Acre----------				
Forest	.6	1.7	3.5	4.5	3.6
Pasture & Hay	1.0	3.9	6.8	10.9	5.4
Tilled Crops*	8.9	22.9	36.8	55.7	22.4
Other	1.8	5.3	8.7	15.7	6.7
Weighted Average	5.0	10.9	14.8	13.2	10.7
	----------Dollars per Acre----------				
Net Returns*					
Continuous Row	124	95	82	41	-
Pasture & Hay	27	18	8	5	-
Difference	97	77	74	36	-

* Tilled crops - Defined as land in tilled crops or rotations
Net Returns - Weighted by soils presently in tilled cropland
Continuous Row - Defined as 50 percent corn, 50 percent soybeans
Pasture & Hay - Pasture and hay not in rotations

Table 21 -- Missouri Bottom Land Acreage by Flooding and Drainage Problems, Northern Missouri River Tributaries Basin.

Item	1000 Acres	Percent
Flooded:		
Well Drained	370.9	20.1
Drainage Problem	858.8	46.5
Total	1229.7	66.6
Flood-Free:		
Well Drained	194.3	10.5
Drainage Problem	422.9	22.9
Total	617.2	33.4
All Bottom Land:		
Well Drained	565.2	30.6
Drainage Problem	1281.7	69.4
Total	1846.9	100.0

The loss in net income from flooding was estimated for the basin area by comparing the "with" flooding condition to the "without" condition. The difference in gross income, production costs, and net returns to land and management is presented for "with" and "without" flooding conditions (Table 22). Presently, the loss in net income on the 1.23 million acres of bottom land subject to flooding is about $32.4 million annually or about $24 per acre flooded.

Future flood losses for the year 2000 were estimated using two different methods. One method assumed land use would remain essentially unchanged (constant land use). The estimated loss in net income, caused by flooding for constant land use in year 2000, is $43 million or $35 per acre flooded. The 33 percent increase in losses over those presently incurred results primarily from higher projected yields.

Another method used to project future flood losses was to assume land use shifts commensurate with the least cost means of meeting projected demand levels for farm commodities. Projections were made "with" and "without" flood control. Land use changes were allowed for both upland and bottom land to meet the projected demand level at minimum costs. Gross income, using this method, was about 20 percent higher than the constant land use method. Gross income increases because of the economic feasibility of increasing tilled cropland acreage, clearing of some forest

land, and added irrigation. Flood losses, as measured by the difference in cost of production between "with" and "without" flooding, were $24.0 million or $20 per acre.

Actual flood losses will probably be somewhere between $24 million and $43 million as indicated by the two methods.

Table 22 -- Missouri Present and Projected Gross Income, Costs and Net Returns "With" and "Without" Flooding, Northern Missouri River Tributaries Basin.

Item	Gross Income	Production Cost	Net Returns
	----------Million Dollars----------		
Present Condition:			
With Flooding	779.79	452.86	346.93
Without Flooding	834.33	454.97	379.36
Difference	34.53	2.11	32.43
Year 2000:			
Constant Land Use			
With Flooding	1047.59	457.11	590.48
Without Flooding	1093.07	459.60	633.47
Difference	45.48	2.49	42.99
Projected Demand			
With Flooding	1253.19	515.48	737.71
Without Flooding	1253.19	491.46	761.73
Difference	0.	24.02	24.02

Year 2000 Land Use	Tilled Crops	Hay and Pasture	Forest Land	Irrigated Land
	----------1000 Acres----------			
Constant Land Use	2986.5	3278.3	1293.0	17.4
Projected Demand				
With Flooding	3474.8	3459.1	622.4	143.1
Without Flooding	3389.8	3189.5	977.9	49.0

Forestry Problems

Livestock grazing, land use changes, and low quality stocking are three major problems in forests. The small tracts of forest land are difficult to manage.

Forest grazing occurs on nearly 66 percent of the forest land and is, by far, the greatest problem. Grazing has detrimental effects on the forest; the most prevalent is erosion. Other undesirable effects include little or no forest reproduction, changes in stand composition in the next rotation, mineral streaking of wood, and the basic lowering of timber quality.

Forest land is rapidly decreasing because of changes in land use. Marginal acres of land are cleared to provide for crop production. Often these acres are land classes IV, V, and above, and are usually susceptible to erosion. Timber cleared for these purposes is usually burned rather than utilized for wood products.

Low quality trees and low stocking levels have resulted in relatively little timber production. Grazing, indiscriminate logging, and lack of good management practices have all contributed to the existing conditions.

B. Erosion

An estimated 100 million tons of soil dislodged annually in the basin constitute a major problem. This erosion causes depletion of the soil resource, pollution of water, and deposition of sediment. In Missouri, sheet and rill erosion from all lands accounts for 88 percent of total gross erosion. The remaining 12 percent of gross erosion is accounted for by gully (6 percent), stream (3 percent), road and other (3 percent). The average annual rate of upland sheet and rill erosion for Missouri is 6.3 tons per acre. The average annual rate of upland sheet and rill erosion for the Missouri portion of the basin is 10.5 tons per acre. On inventory land, 68 percent of sheet and rill erosion occurs on tilled land (Table 23). In contrast, only 6 percent of sheet and rill erosion occurs on forest land and 23 percent occurs on pasture and hayland. Soils with slopes from 5 to 9 percent account for 47 percent of inventory land and 48 percent of sheet and rill erosion. Tilled land in this slope group accounts for only 18 percent of inventory land but 38 percent of sheet and rill erosion. Tilled soils on 14 percent or greater slopes have the highest erosion rate, 56 tons per acre. Although they comprise only 3 percent of inventory land, they account for 14 percent of the erosion.

Although several conservation practices are available to reduce erosion on the 2.052 million acres of tilled inventory cropland in the Missouri portion of the basin, 53.5 percent is presently farmed without conservation measures (Table 24). This land is farmed in straight rows using conventional tillage methods. Sheet and rill erosion occurs on this land at an average rate of 31 tons per acre. Contour farming is used on 28 percent of tilled inventory land. Minimum tillage is the second most popular practice (22 percent), followed by terracing (7 percent), no till (2 percent), and stripcropping (0.7 percent).

Table 23 -- Missouri Distribution of Major Land Use and Sheet and Rill Erosion by Upland Slope Groups, Northern Missouri River Tributaries Basin

Land Use	Slope Group A&B 0 to 5%	C 5 to 9%	D 9 to 14%	E 14%	Total
	Percent				
Forest Land					
Inventory Land	1.1	3.3	1.5	10.3	16.2
Erosion	.1	.5	.5	4.4	5.5
Pasture and Hayland					
Inventory Land	7.4	23.8	4.4	10.8	46.4
Erosion	.7	8.8	2.8	11.0	23.3
Tilled Cropland [1/]					
Inventory Land	9.8	17.6	2.5	2.6	32.5
Erosion	8.1	37.7	8.6	13.7	68.1
Other Land					
Inventory Land	1.1	2.6	.4	.8	4.9
Erosion	1.2	1.3	.3	1.3	3.1
Total					
Inventory Land	19.4	47.3	8.8	24.5	100.0
Erosion	9.1	48.3	12.2	30.4	100.0

1/ Defined as land in tilled crops or rotations.

Table 24 -- Missouri 1974 Distribution of Inventory Cropland Erosion and Erosion Rates by Conservation Practice, Northern Missouri River Tributaries Basin.

Conservation Practice	Conventional Till	Minimum Till	No Till	Total
	Erosion Rate Tons per Acre			
Up and Down	30.59	12.81	7.55	26.17
Contoured	17.73	7.57	4.19	14.87
Contoured & Terraced	12.06	4.98	2.57	9.94
Stripcropped	5.28	2.59	1.55	4.28
Weighted Average	26.44	10.88	6.08	22.39
	Area Percent			
Up and Down	53.5	15.3	1.6	70.4
Contoured	15.3	5.1	.6	21.0
Contoured & Terraced	5.2	1.8	.2	7.2
Stripcropped	.5	.2	-	.7
Total	74.5	22.4	2.4	99.3*
	Erosion Percent			
Up and Down	73.1	8.8	.5	82.4
Contoured	12.1	1.7	.1	13.9
Contoured & Terraced	2.8	.4	-	3.2
Stripcropped	.1	-	-	.1
Total	88.1	10.9	.6	99.6*

*Does not add to 100 percent due to rounding

Subbasin Erosion

The Tarkio and Nodaway River Subbasins have the most severe subbasin erosion problems in the basin and also the most severe sheet and rill erosion on uplands (Table 25). Sheet and rill erosion on upland cropland in the Chariton and Platte Subbasins is also very severe. Stream erosion is most severe in the Nodaway and Chariton Subbasins. However, the most severe stream erosion reach is along the West Fork Grand River in Missouri.

Table 25 -- Erosion Rates by Erosion Types and Hydrologic Units, Northern Missouri River Tributaries Basin.

Hydrologic Unit Codes	Subbasin Descriptions	Average Annual Erosion			
		Gross Erosion	All Upland Sheet and Rill	Upland Sheet and Rill on Tilled Land	Gully
		----------Tons per Upland Acre--------			
10240005 10240011	Tarkio River and Smaller Missouri River Trib's	21.4	19.6	29.2	1.2
10240009 10240010	Nodaway River	20.7	17.6	28.7	1.8
10240012	Platte and 102 Rivers	12.6	11.0	23.0	1.2
10300101	Direct Trib's to Missouri River	12.8	11.7	18.6	0.1
10280101	Upper Grand River	9.6	7.8	19.3	1.4
10280102	Thompson River	6.5	5.1	16.3	0.7
10280103	Lower Grand River	8.9	8.1	20.3	0.3
10280201 10280202 10280203	Upper Chariton River Chariton River Little Chariton R.	11.2	9.8	27.2	0.5

The most devastating water-caused erosion problem comes from sheet and rill erosion. Together they remove productive topsoil, and with time, expose agriculturally less productive subsoils and parent materials. Row crop production on 7,000 acres has ceased as a result of excessive erosion. Soils on which reduced crop production is most noticeable include: Adair, Armster, Armstrong, Gara, Grundy, Higginsville, Lagonda, Lomoni, Pershing, and Shelby.

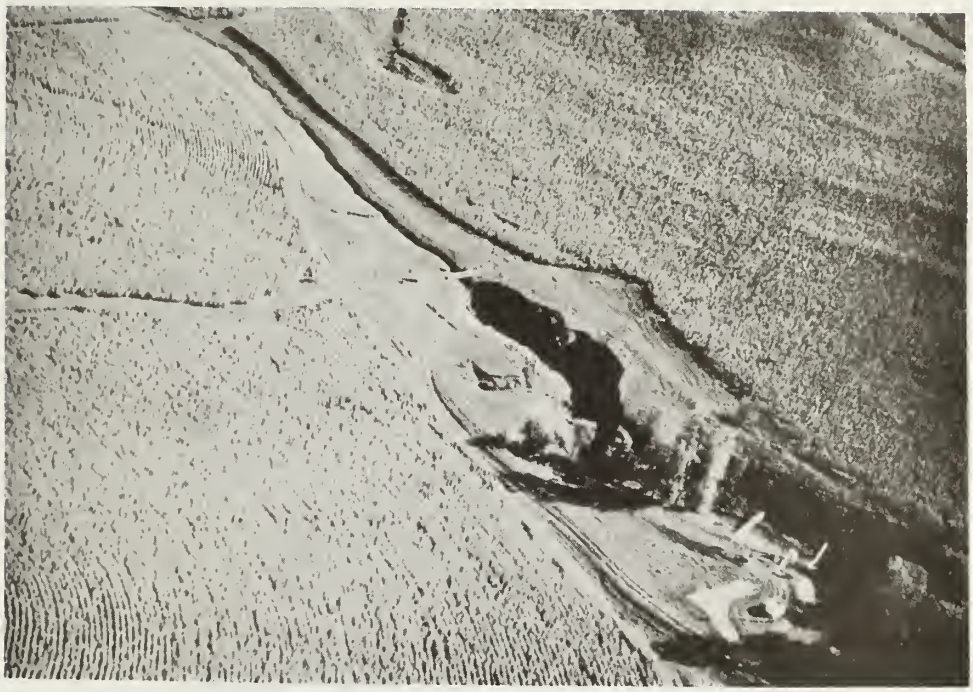
SHEET AND RILL EROSION

Sheet erosion is the removal of a relatively uniform layer of soil. Rill erosion is the formation of shallow channels that can be smoothed out by normal cultivation.
Daviess County, Missouri *June 22, 1976*

In general, upland sheet and rill erosion decreases from west to east. Deep loess in the west allows continued cropping on even the steeper slopes. Cropland decreases from 67 percent in the Tarkio River Subbasin to 53 percent in the Chariton River Subbasin. Highly erosive soils are found in all subbasins. Soil Resource Groups shown in Table 26 account for most of the excessive sheet and rill erosion in the Missouri portion of these subbasins.

Gully density continues to increase as uncontrolled discharges cause new overfalls and rejuvenate headwall movement. Unimpeded rill erosion results in isolated field gullies. Most potential field gullies are erased by cultivation or impeded by conversion of the eroded area to grass. Grass drain control of gullies is common in Missouri. Slumping and channel scarp (overfall) movements are characteristic of old gullies in the deep loess areas of the basin. Land use changes and management practices that concentrate water are the primary causes of present accelerated gully growth.

GULLY EROSION



Gully erosion is defined as the erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depth, ranging from 1 to 2 feet to as much as 75 to 100 feet.

Aerial view showing waterway draining into gully near Treynor, Iowa.
Sec. 35, T47N, R42W *October 1970*

In Missouri, stream deepening is not a major cause of present accelerated gully growth. In Iowa, stream deepening is a major cause of present accelerated gully growth in West Tarkio River, Little Tarkio River, Upper Reaches of 102 River and West Grand River.

Table 26 -- Selected SRG Erosion by Subbasins in Missouri, Northern Missouri River Tributaries Basin.

Subbasins	SRG's*	Estimated Percent of Subbasin Erosion	Estimated Percent of Land	Estimated Average Annual Erosion (tons/ac)
Tarkio River Subbasin	104	10	15	13
	106	17	14	24
	108	27	17	20
	705	16	11	28
Nodaway River Subbasin	106	22	19	20
	108	20	11	31
	126	21	14	26
	705	18	15	20
Platte River Subbasin	106	15	13	14
	124	24	24	12
	126	23	14	20
Direct Tributaries Below Platte River Subbasin	106	12	13	10
	124	35	29	13
Upper Grand River Subbasin	106	3	4	6
	124	28	29	8
Thompson River Subbasin	124	26	26	6
	126	15	11	9
	705	31	22	9
Lower Grand River Subbasin	124	37	36	9
	705	25	17	13
Chariton River Subbasin	124	21	25	8
	705	32	21	15
	706	21	10	22

* Soil Resource Group - aggregations of soil capability classes with similar management characteristics such as slope, texture, depth of topsoil, yield capacity and drainage. Table 27 shows the relationship between selected soil resource groups, capability classes, and typical soil series.

Table 27 -- Missouri Selected Soil Resource Groups, Northern Missouri River Tributaries Basin.

Upland Soil Resource	Capability Class	Typical Soil Series
SRG 104	2E01	Marshall B Slope
	2E04	Sharpsburg B Slope
SRG 106	3E01	Marshall C Slope
	3E04	Sharpsburg C Slope
		Gara C Slope
SRG 108	4E01	Lindley D Slope
	4E04	Gara D Slope
		Shelby D Slope
SRG 124	3E02	Shelby C Slope
	3E05	Grundy C Slope
		Seymour C Slope
		Adair C Slope
SRG 126	4E05	Shelby C Slope
	4E07	Lagonda C Slope
	4E08	
SRG 705	6E01	Shelby D Slope
	6E04	Lindley E Slope
	6E05	Gara E Slope
SRG 706	7E01	Lindley F Slope
	7E04	Shelby E Slope
	7E07	

Stream Erosion

Streambank erosion is a severe problem in the basin (Map 16). Up to 14 acre feet per mile of streambank erosion occur annually along reaches of the Upper Grand River.

Streambed conditions were identified as deepening, filling, and stable (Map 17). Stream channel deepening is occurring in streams least affected by bedrock and bedload sediment.

According to a 1977 survey by the Missouri Department of Conservation, the Missouri portion of the basin was once drained by 10,367 miles of streams. Channelization in the Missouri portion of the basin has decreased stream mileage to 9,667 miles, a loss of 700 miles. Channelization is a principal cause for accelerated bank erosion in the basin and for reducing stream miles (Map 11).

STREAMBANK EROSION

Up to 14 ac. ft. per mile of soil is lost annually in similar stream reaches.
Hwy. 136 Crossing Weldon River
Sec. 28, T65N, R24W - May 12, 1977

Road and Other Erosion

The bare and scarred surfaces and banks of some roads are unappealing to the eye. Rutted surfaces and roadside gullies are hazardous to traffic.

U. S. DEPARTMENT OF AGRICULTURE

LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- COUNTY SEATS & TOWNS OVER 15,000
- DRAINAGE
- LAKES
- INTERSTATE HIGHWAY
- U.S. HIGHWAY
- BASIN BOUNDARY
- FIELD INSPECTIONS

EROSION KEY

AC.FT PER MILE	
0. TO 0.09	SLIGHT
0.1 TO 0.9	MODERATE
1. TO 14	SEVERE

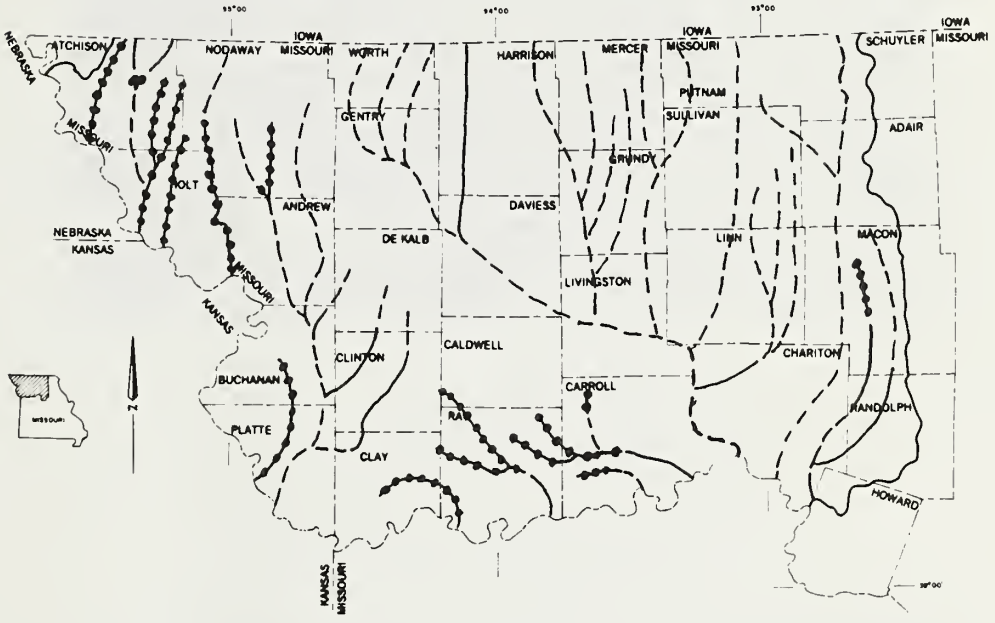
MAP 16

1977
STREAM BANK EROSION
NORTHERN MISSOURI RIVER TRIBUTARIES BASIN
MISSOURI AND IOWA

SOURCE
FAMILY OF MAP SCS ORWG NO. 5,R-35,055 (3-78),
AND INFORMATION FROM FIELD TECHNICIANS
LAMBERT CONFORMAL CONIC PROJECTION

5-30-78
5,S-36,926

Channels deepened by excavation commonly cause unstable overfalls at road ditch inlets. Where overfalls are present, unless drop inlets are constructed, road ditches erode severely until a stable grade is reached.



LEGEND

STATE BOUNDARY
COUNTY BOUNDARY
BASIN BOUNDARY

STREAMBED CONDITIONS

DEEPENING
FILLING
STABLE

MAP 17
STREAMBED CONDITIONS
(1977)
MISSOURI

NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA

Mined areas, construction sites, and new housing developments are commonly sites of excessive erosion and locally excessive sediment. Onsite average annual erosion rates up to 200 tons per acre are only equalled by the most active gullies.

ROAD EROSION

Roadside gullies endanger traffic and contribute to stream filling.
Clay County, Missouri May 1, 1972

CONSTRUCTION SITE EROSION

Up to 200 tons per acre of soil loss from construction sites has been documented.
Clay County, Missouri May 1, 1972

Status of Soil Depletion

The cumulative effect of past soil erosion is categorized in soil erosion phases. The scale ranges from phase 0, which represents essentially no erosion, to phase 4, which represents almost complete depletion of the topsoil. The average annual rate of erosion on tilled upland ranges from 30 tons per acre in Nodaway, Chariton, and Tarkio, to 20 tons per acre in the other subbasins. At these rates, 1 inch of topsoil is removed in 5 and 7½ years, respectively.

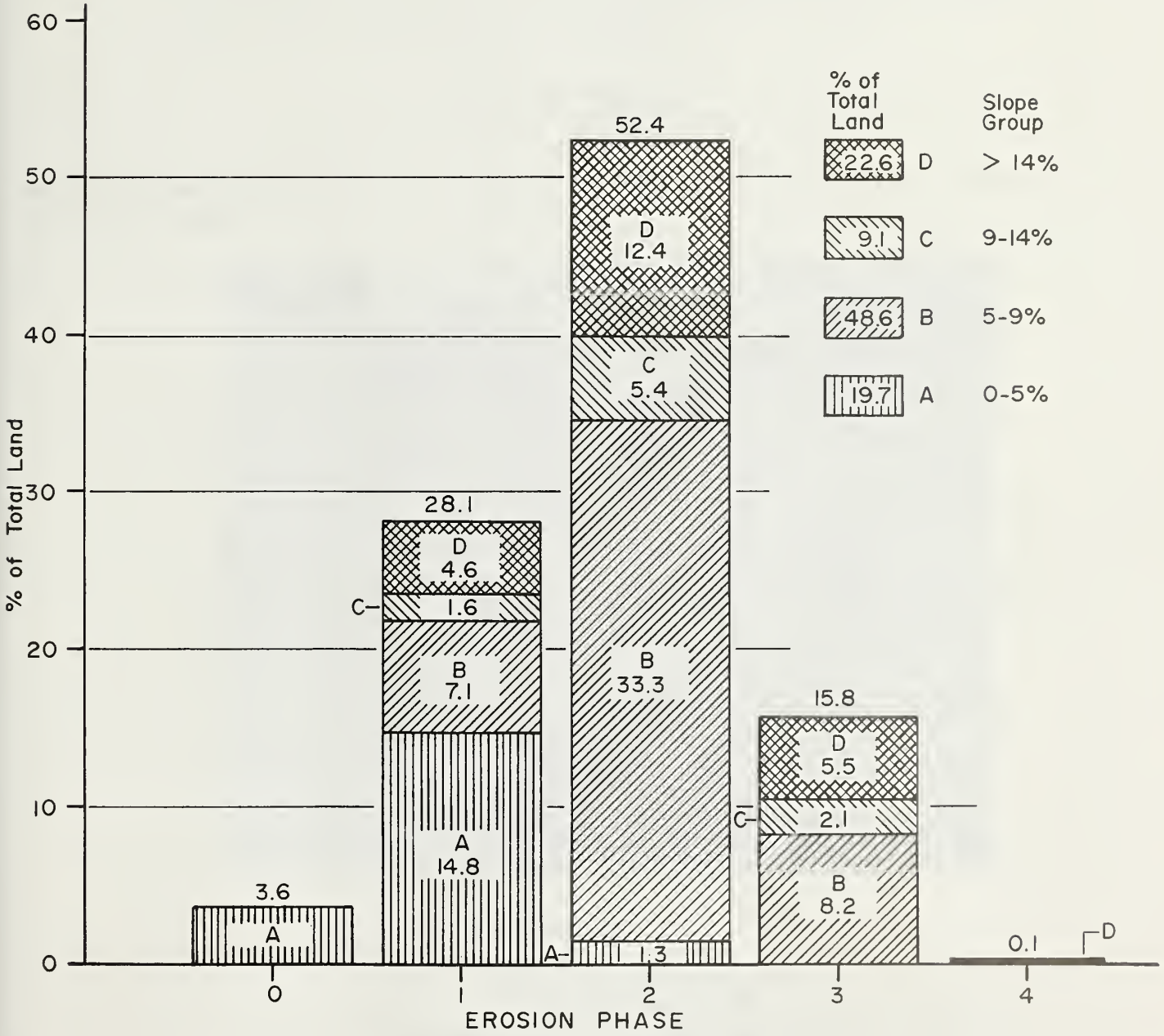
Only 3.6 percent of the upland soils in the basin are in erosion phase 0 (Figure 8). These soils have slopes of less than 5 percent. About 28 percent of the soils are in phase 1, representing slight erosion. The majority of the soils in this phase have slopes of less than 9 percent. More than half of the upland soils (52.4 percent) have eroded to the extent that they are in phase 2 with only 2 to 6 inches of surface topsoil remaining. Almost all of the soils in this phase have slopes of more than 5 percent. About 16 percent of the soils are in erosion phase 3 exhibiting severe erosion and exposed subsoil. Less than 1 percent of the soils are in phase 4 and eroded to the point where essentially all of the topsoil is gone.

The soil depletion process usually occurs in the following manner. A virgin soil is plowed and placed into crop production. Accelerated erosion begins, and lacking conservation measures, continues until most of the topsoil has been depleted. Because of the depletion, row crop yields decrease and input costs increase to the extent that row crop production is feasible only at very high crop prices. At some point in time, production of row crops is no longer profitable and the land is converted to permanent pasture or forest.

This process has been modified somewhat in recent years by the application of other production inputs. Fertilizer, lime, and other yield-increasing inputs have offset to some degree the yield-reducing effects of erosion. Use of these inputs permits a soil to remain in crop production for a longer period of time than would otherwise be profitable. Meanwhile the inherent capacity of the soil has been irretrievably diminished because of the deterioration of the complex structure, texture, chemical nature, and water holding capacity of the soil.

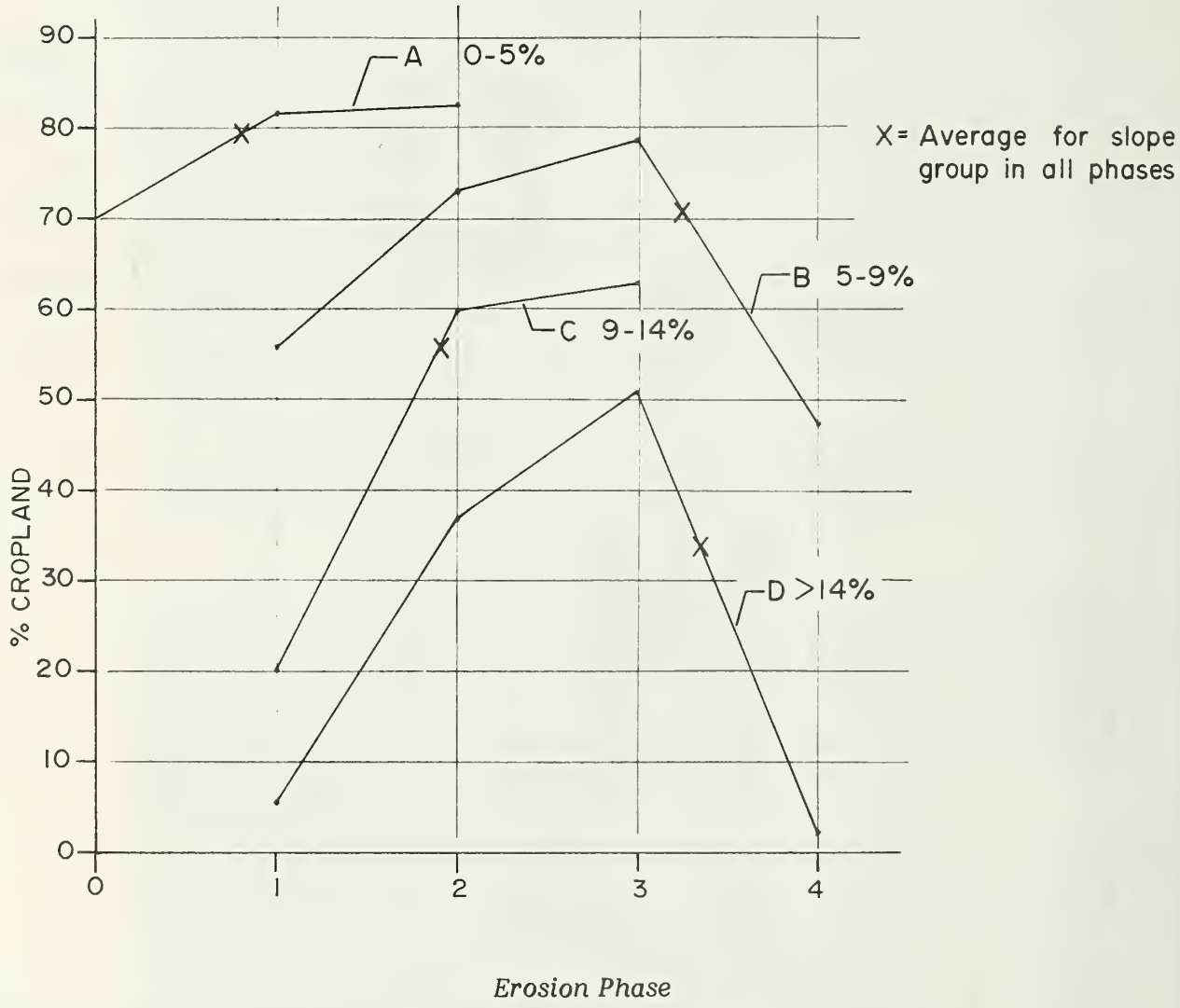
There is evidence that the majority of the basin's upland soils are in the middle of this cycle. It appears that once a soil is placed in cropland production, there is a tendency for it to remain in cropland until the topsoil is depleted. This is illustrated by data in Figure 9 which relates the percentage of land used as cropland by slope groups to erosion phases. Note that the percentage of land used for cropland increases within each slope group as the severity of erosion increases from phase 0 to phase 3. When soils have eroded to a point where they are classified as phase 4, however, the percent devoted to cropland drops significantly. Soil depletion would be much higher if more of the steeper soils had been used for cropland production. The tendency to crop a lower percentage of the steeper soils is indicated by the progressively lower curves for each slope group. For example, about 79 percent of the land in slope group A is cropland compared to only a third of slope group D.

Figure 8 -- Percent distribution of Land in Missouri by Slope Group and Erosion Phase, Northern Missouri River Tributaries Basin.



0 - Deposition; more than 10 inches of topsoil
1 - Slight erosion; over 6 inches of topsoil
2 - Moderate erosion; 2-6 inches of surface remaining
3 - Severe erosion; subsoil exposed, small gullies
4 - Very severe erosion; badly gullied, cultivation difficult

Figure 9 -- Percent Distribution of Cropland in Missouri by Erosion Phase, Northern Missouri River Tributaries Basin.



0 - Deposition; more than 10 inches of topsoil
1 - Slight erosion; over 6 inches of topsoil
2 - Moderate erosion; 2-6 inches of surface remaining
3 - Severe erosion; subsoil exposed, small gullies
4 - Very severe erosion; badly gullied, cultivation difficult

Sediment

Excess sediment creates other erosion related problems. Suspended sediment concentrations in streams are so high it restricts the development of aquatic life. Channelization and bedload sediment prohibit development and maintenance of stream pools essential to increased fish diversity, increase in fish size, and increase in fish populations. Sediments, deposited on flood plains, are often damaging to productivity. Sediment damage to flood plain soils is expected to increase.

BEDLOAD SEDIMENT

Bedload sediment eliminates stream pools, adversely affects streambed productivity, and reduces surface flows.
Thompson River county road crossing two miles east of Brimson, Missouri.
Sec. 22, T62N, R25W *May 10, 1977*

Some eroded soil is deposited in fields. Significant quantities of sediment in the transport system are deposited on flood plains, in stream channels, and in ponds and reservoirs (Figure 10). Estimates of sediment caused water storage losses by the year 2000 are shown in Table 28. More than five million tons of sediment have been deposited in the lakes of the Swan Lake National Wildlife Refuge in the last 39 years. An estimated 40 million tons of sediment is discharged annually from the basin into the Missouri River. Sediment in transport comprises 40 percent of the soil eroded in the basin and constitutes 45 percent of the suspended sediment passing Hermann, Missouri (Figure 11).

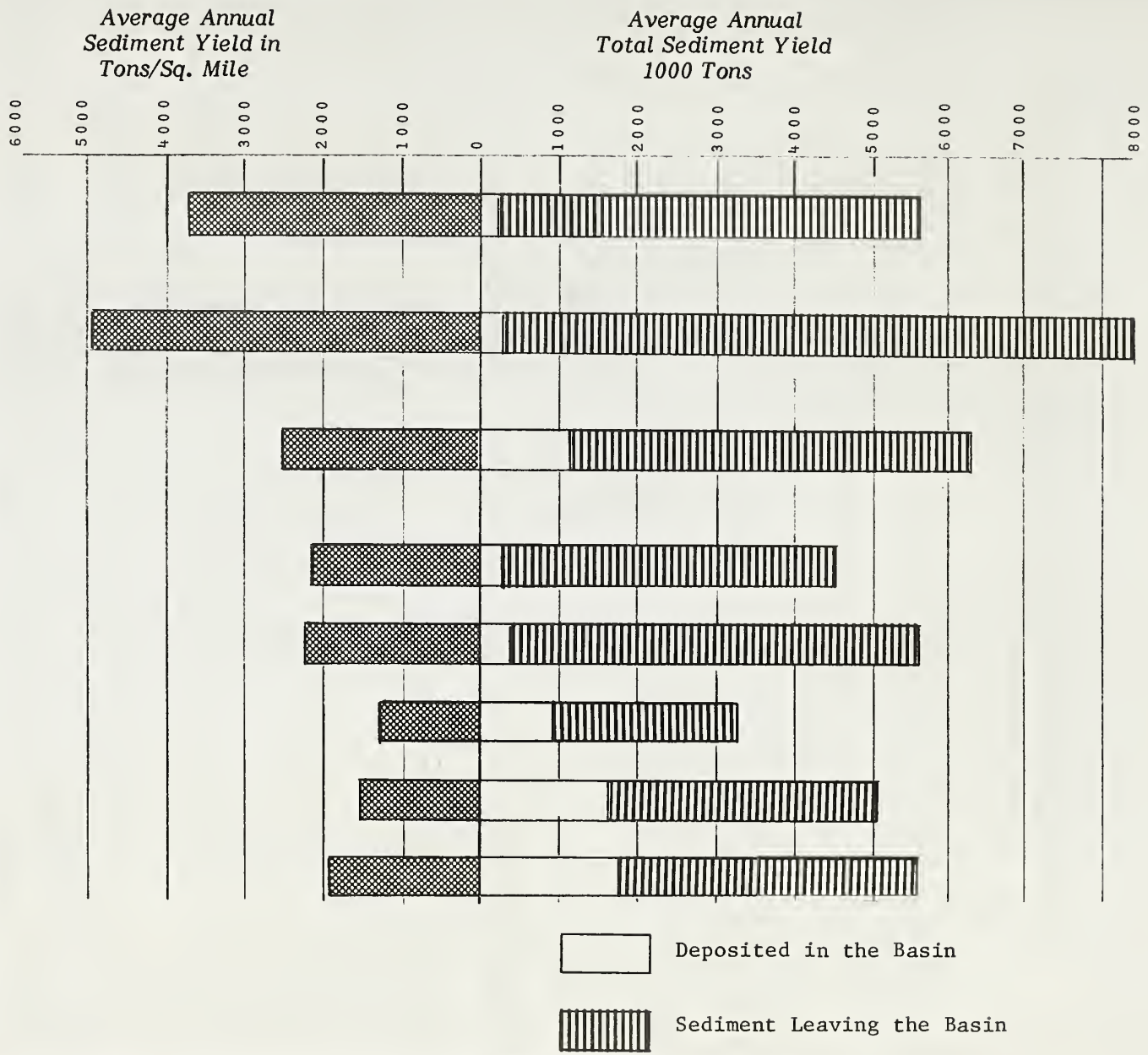
Overall Erosion and Sediment Evaluation

The severity of problems within the subbasins was evaluated by the work group (Table 29). These judgmental ratings were based on the findings of the Iowa and Missouri Erosion and Sediment Inventories.

SEDIMENT DAMAGE

Silt deposition smothers immature plants and increases tillage costs.
Tributary to Platte River
Castile Creek Flood Plain Buchanan County, Missouri
Sec. 11, T55N, R34W April 19, 1977

**Figure 10 — Predicted Average Annual Sediment Yields by Hydrologic Unit Codes, Northern Missouri River Tributaries Basin, Iowa and Missouri*



HYDROLOGIC UNIT CODES	SUBBASIN DESCRIPTIONS
10240005 10240011	Tarkio River and Smaller Missouri River Trib's
10240010	Nodaway River
10240012 10240013	Platte and 102 Rivers
10300101	Direct Trib's to Missouri River
10280101	Upper Grand River
10280102	Thompson River
10280103	Lower Grand River
10280201	Upper Chariton River
10280202	Chariton River
10280203	Little Chariton River

* *This figure portrays sediment in transport. It should not be confused with soil loss. The difference between total soil loss and total sediment leaving the basin is much greater than total sediment deposited in the basin.*

Table 28 -- Estimated Year 2000 Storage Losses in Selected Missouri Public Water Reservoirs, Northern Missouri River Tributaries Basin

Regional Planning Commissions and Cities	Drainage Area (acres)	Surface Area (acres)	1977 Water Storage (Ac. Ft.)	Year 2000 Estimated Storage Loss (Ac. Ft.)	Est. 2000 Water Storage (Ac. Ft.)
NW Mo. Regional P.C.					
King City	554	40.90	427.25	16.59	410.66
Mo.-Kan. Regional P.C.					
Cameron	3144	143.30	1704.55	77.95	1626.60
Gower	193	14.40	135.50	6.66	128.84
Maysville	2086	44.00	296.65	54.95	241.70
Savannah	548	19.30	161.35	17.13	144.22
Mid America Regional P.C.					
Dearborne	370	7.40	56.00	9.47	46.53
Green Hills Regional P.C.					
Bethany	958	94.20	1633.46	27.21	1606.25
Breckenridge	423	14.40	119.50	13.11	106.39
Brookfield	685	118.00	1885.00	8.77	1876.23
Bucklin	361	17.00	135.36	8.75	126.61
Green City	60	6.00	45.12	1.68	43.44
Hamilton	1200	35.50	149.78	33.47	116.31
Harrison PWSD #1	3136	38.50	214.25	77.75	136.50
Jamesport	1208	28.00	201.00	33.69	167.31
Linneus	467	15.20	196.00	14.85	181.15
Mercer	946	11.10	82.75	25.71	57.04
Ridgeway	83	2.20	15.25	2.87	12.38
Unionville	1836	70.00	677.02	50.47	626.55
NE Mo. Regional P.C.					
Downing	220	18.00	117.24	5.69	111.55
Schuyler PWSD #1	566	31.00	243.30	13.27	229.93
Mark Twain Regional P.C.					
Atlanta	180	16.10	158.80	4.14	154.66
La Plata	400	19.00	141.80	8.62	133.18
New Cambria	112	8.50	77.25	3.03	74.22
Higbee	103	15.00	108.59	2.48	106.11

Figure 11 -- Missouri River Suspended-Sediment Flow Regime (1970 to 1978), Northern Missouri River Tributaries Basin, Iowa and Missouri. (SOURCE: Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi)

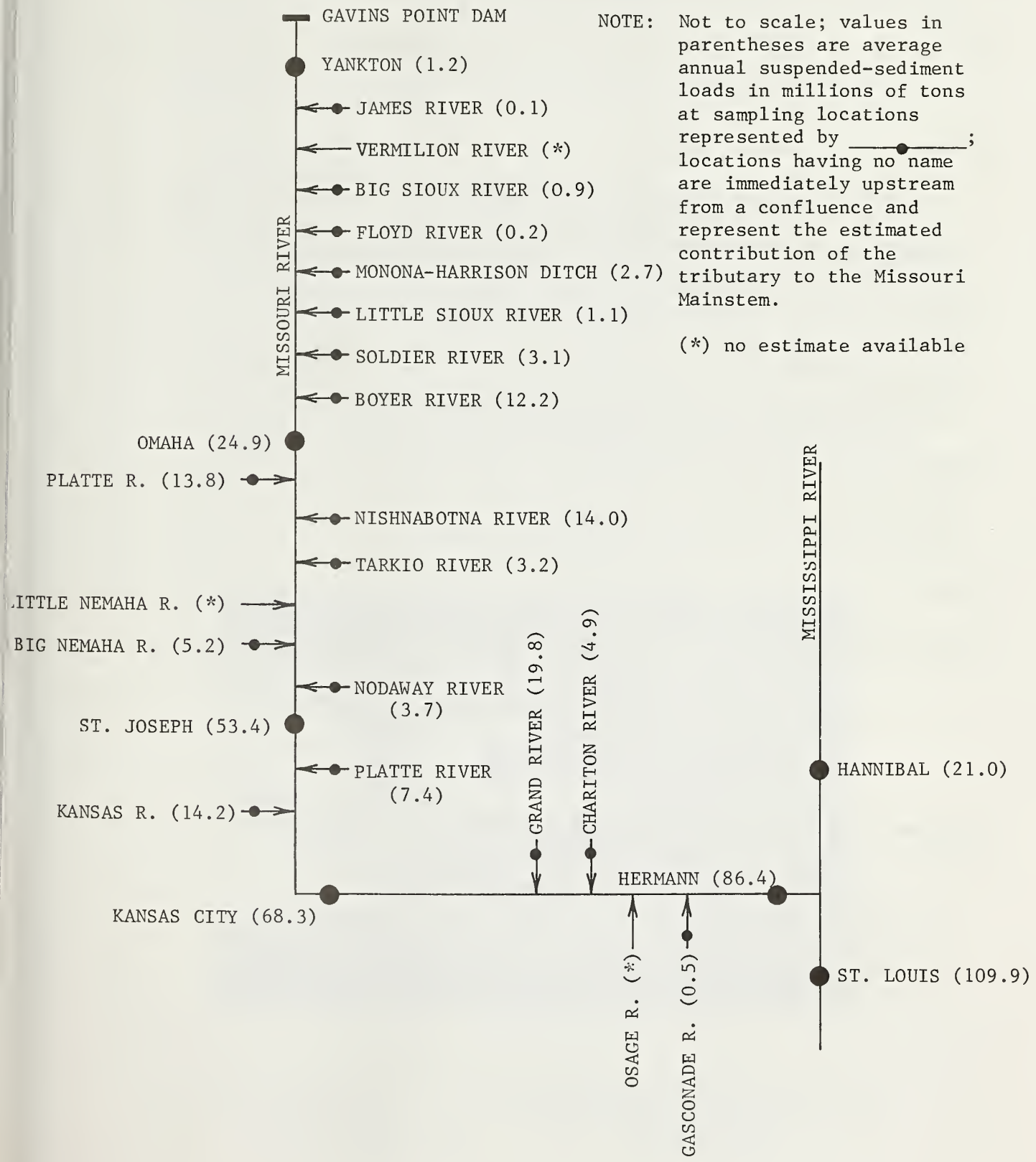


Table 29 — Overall Erosion and Sediment Evaluation, Erosion and Sediment Work Group Members, Northern Missouri River Tributaries Basin, Iowa and Missouri

Problems	SUBBASINS							
	Tarkio R. & Smaller Mo. R. Tribs.	Nodaway R.	Platte R.	Direct Tribs. Below Platte River	Upper Grand River	Thompson R.	Lower Grand River	Chariton R.
	Problem Severity*							
Erosion	1	1	2	2	3	4	3	2
Sheet and Rill Erosion on Tilled Land	1	1	1	2	2	2	2	1
Gully Erosion	2	1	2	4	2	3	4	3
Streambank Erosion	3	1	3	5	2	2	2	1
Sediment	1	1	2	2	2	3	3	2
Channel Fill	4	2	1	4	1	3	2	4
Reservoir Capacity Loss	2	2	2	2	2	2	2	1
Sediment Damage	4	3	1	5	3	3	2	2
Channelization	3	2	3	5	3	1	4	3
Overall Sediment and Erosion Rating	2.3	1.6	1.9	3.4	2.2	2.6	2.7	2.1

*Problem Severity Numerical Values:

1 - Very Severe
2 - Severe
3 - High
4 - Moderate
5 - Slight

C. Water Quality (Missouri)

The principal water quality problems identified in the streams are suspended sediment, water temperatures, acidic waters, pesticide spills, and loss of pools. The weakness of base flows affects all the above.

Missouri water quality criteria are commonly exceeded for manganese and fecal coliform and excessive aquatic plant growths are a concern to the Missouri Department of Conservation.

Suspended Sediment

Suspended sediment concentrations in runoff water are high. The lowest estimated average annual suspended sediment concentration is 2,000 ppm at the mouth of the Chariton River; the highest estimated average annual suspended sediment concentration is 11,000 ppm at the mouth of the Tarkio River. High suspended sediment concentrations in runoff water contribute to a low diversity of fish species in the basin's streams.

Base Flows

Although not in itself a water quality problem, the sparsity and weakness of base flows increases the adverse effects of excessive aquatic plant growths, water temperatures, acidic waters, pesticide spills, and loss of pools.

DRY STREAMBED

Dry streambeds are common occurrences in the smaller streams of the basin.
Castile Creek *Buchanan County, Missouri*
Sec. 24, T55N, R34W *April 19, 1977*

Of the 9,667 miles of streams recognized by the Missouri Department of Conservation, only 1,836 miles support perennial flows. Even in the perennial streams, base flows are commonly so low as to be hazardous to large fish. Weak base flows in perennial streams are also highly susceptible to high temperatures, high concentrations of toxic materials, and algae blooms. All of these conditions are detrimental to fish.

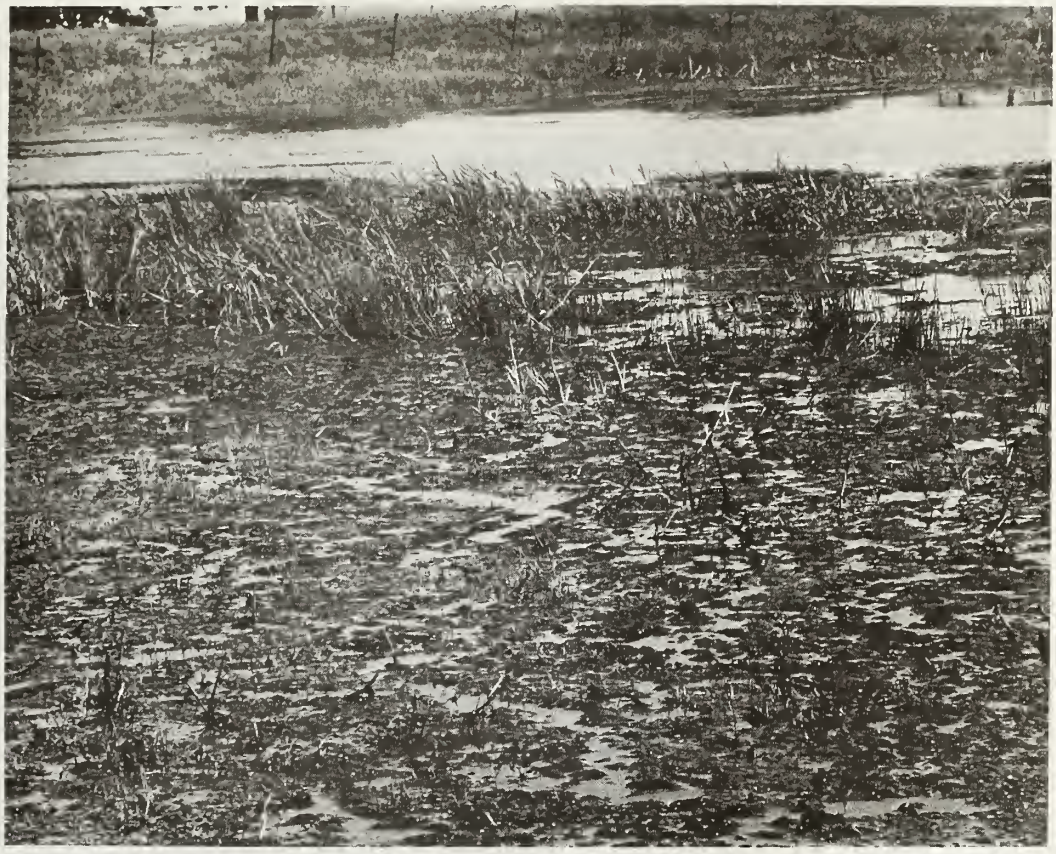
WEAK BASE FLOW

Weak base flows are highly susceptible to temperature fluctuations, concentration of toxic materials, and algae blooms.
Platte River Nodaway County, Missouri
Sec. 22, T63N, R34W June 8, 1977

Excessive Aquatic Plant Growths

Excessive aquatic plant growths have been reported by the Missouri Department of Conservation. The incidence of these growths can not be related to any specific cause. They are a result of a combination of conditions including temperature, nutrients, sunlight and flow conditions. Prolific growths of algae and higher aquatic plants pose danger of oxygen poisoning to fish, while massive die-offs of algae and aquatic plants pose danger of oxygen starvation to fish.

EXCESSIVE AQUATIC PLANT GROWTHS



Prolific aquatic plant growths may cause oxygen poisoning and massive die-offs from oxygen starvation.

Water Temperatures

Warm waters are another deterent to fish development and fish diversity. Water temperatures in excess of 32°C have been recorded in the basin's streams. These temperatures are detrimental to the growth of largemouth bass, drum, bluegill, and crappie. Temperatures in excess of 27°C are detrimental to the spawning and egg development of catfish, buffalo, threadfin shad, and gizzard shad. Because of the shallow nature of low flows in the basin's streams, water temperature in excess of 27°C probably occurs quite frequently during fish spawning and fish egg development.

Acidic Waters

Waters with pH's below 6.5 have been determined to be detrimental to fish, and waters with pH's below 5.0 have been determined to be detrimental to domestic water supplies.

High sulfate concentrations contribute to acidic conditions in base and normal flows in the East Fork Chariton River. The pH at the Huntsville USGS gage on the East Fork of Chariton River fell below 6.5 in 12 of 81 samples. The lowest recorded pH at this station was 2.6 on November 13, 1963. The only other station in the basin to record a pH below 6.5 was at Lucerne, Missouri, USGS gage station on Medicine Creek, on July 27, 1977.

The streams most adversely affected by low pH and high concentrations of iron and manganese are North Claybank Creek, Dark Creek, and Sugar Creek. The lower 3.5 miles of the East Fork of the Little Chariton River are occasionally degraded by acid mine drainage. Bevier Lake, with a surface area of 10 acres, is also adversely affected occasionally by acid mine drainage.

Pesticide Fish Kills

Pesticides were documented by the Missouri Department of Conservation as being responsible for four fish kills in the Missouri portion of the basin between 1965 and 1977. The bodies of water affected were Hess Pond - 1971, Little Tarkio River - 1972, Platte River - 1974, and Jamesport City Reservoir - 1976.

IRON PRECIPITATE

Yellow-boy, a common result of acid mine drainage. The iron released in acid production is progressively oxidized and, eventually finding a suitable environment, comes to rest as in the above photograph.

FISH KILL

Oxygen starvation, acid drainage, and pesticide kills are documented causes of fish kill in the basin.

Pool Loss

Loss of pools is possibly the single most damaging factor to fish inhabiting the basin's streams. Pools provide resting areas during normal flows and survival areas during periods of no flow. Pools are being eliminated by continued channel straightening and an increasing sediment bedload. Of the 9,667 miles of stream in the basin, 1,212 miles have been adversely affected by channelization.

POOL-LESS STREAM

Pool losses may be the single most limiting factor to fish diversity in the basin.
Hundred and Two River Nodaway County, Missouri
Sec. 35, T65N, R35W June 9, 1977

Manganese

The maximum limit for manganese in drinking water was set not for toxological reasons but to prevent objectionable and tenacious stains to laundry and plumbing fixtures. Missouri's criteria for manganese is commonly exceeded in running waters. These natural high backgrounds may seasonally cause criteria violations in impounded waters.

Fecal Coliform

Missouri water quality criteria for fecal coliform do not apply when streams or lakes are affected by stormwater runoff. Fecal coliform counts in Missouri runoff waters are normally high. The inflow of fecal coliform to Missouri reservoirs is normally high. However, fecal coliform survival in reservoirs is short and runoff events transmitting high loads of fecal coliform intermittent. Missouri reservoirs are cited for fecal coliform water quality criteria violations only when criteria violations are consistent.

Overall Stream Water Quality Evaluation

The work group's evaluation of the present severity of stream water quality problems within the subbasins is displayed (Table 30). These judgmental ratings were based on the findings of the Water Quality Inventory.

D. Energy (Missouri)

One of the concerns that has resulted in water and land quality deterioration and which may continue to cause problems in the future is the extraction of coal for energy. In the past, surface mining caused (1) excessive dust, (2) hazardous traffic conditions, (3) abandoned wastelands, (4) degraded soils, and (5) degraded streams. Some of these problems have been addressed by recently enacted mining regulations.

However, abandoned wastelands and their effects persist. Many of these lands are nonproductive, aesthetically unappealing, sediment sources, and some are sources of acidic waters. The energy work group investigated the effect of past coal mining and possible future mining on the land and water resources.

Approximately 13,000 acres of land in the basin have been depreciated by coal mining. The majority of these acres are in Macon and Randolph Counties. Map 18 shows the status of land affected by all mining as of 1979. Greater than 50 percent of this land would have qualified as prime land. Coal mining in the future may affect an additional 100,000 acres in the tier of counties; Putnam, Schuyler, Adair, Macon, and Randolph; bounded by the Chariton and Little Chariton Subbasins. The effects of future coal mining on the basin's soil resource are dependent upon the effectiveness of existing mine reclamation laws.

Lands restored to equivalent agricultural productivity will incur an agricultural productivity time loss of five to ten years. The total acreage out of agricultural production in any one year is not likely to exceed 2,000 acres if the reclamation laws are strictly enforced.

Many problem areas of acid runoff have been identified. All mined areas in the intensely mined eastern tier of counties appear to be potential sources of acidic runoff and acidic seepage.

The Little Chariton River drains 14,517 acres of mined land, 11,995 of which are abandonded and largely responsible for acid drainage into 29 stream miles and a 6-acre lake. The majority of mining in the Little Chariton River, approximately 11,000 acres, has been in the East Fork Chariton River Watershed. Coal mine drainage has been responsible for one fish kill and water quality degradation of 22 miles of the East Fork Chariton River and its tributaries. Tributaries identified as having water quality problems caused by coal mining include Dark Creek, Sugar Creek, Collier Branch, Silver Creek, and Coal Creek.

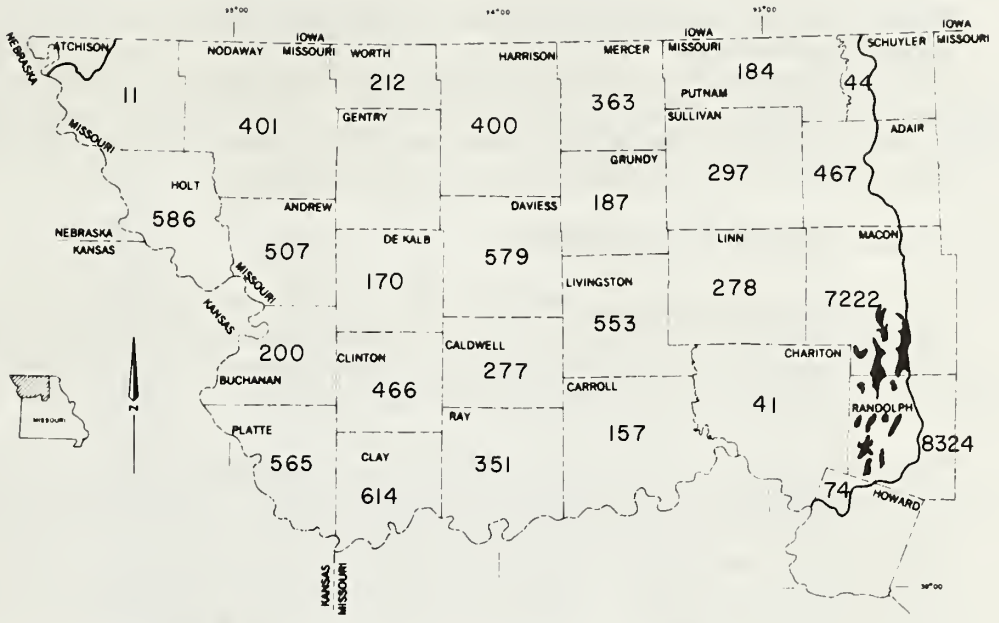
Middle Fork of the Chariton River drainage system contains about 3,600 acres of coal mined lands, a large portion of which is abandoned and drains into Thomas Hill Lake. One 6-acre lake and seven stream miles were identified as affected by abandoned mine drainage. Major waters involved in coal land drainage are the Middle Fork of Chariton, Thomas Hill Lake, and the North and South Forks of Claybank Creek.

Table 30 -- Overall Water Quality Evaluation, Missouri Water Quality Work Group Members, Northern Missouri River Tributaries Basin.

Problems	Subbasins							
	Tarkio R. & Smaller Mo. R. Tribs.	Nodaway R.	Platte R.	Direct Tribs. Below Platte River	Upper Grand River	Thompson R.	Lower Grand River	Chariton R.
	Problem Severity*							
Suspended Sediment	1	1	1	2	1	1	1	2
Loss of Permanent Pools	1	1	2	4	1	1	1	1
Poor Base Flows	2	1	2	2	3	2	4	3
Water Temp. 32° C.	1	1	2	4	2	2	3	3
Dissolved P in Low Flows	2	2	2	3	1	2	2	2
Excessive Aquatic Plant Growths	2	2	4	2	2	3	2	2
Acidic Waters	5	5	5	5	5	5	4	2
Sulfates	4	4	4	4	3	3	3	2
Iron	2	3	4	4	1	1	1	2
Pesticide Fish Kills	4	4	4	4	4	4	4	4
Overall Water Quality Rating	2.4	2.4	3.0	3.4	2.3	2.4	2.5	2.3

*Problem Severity Numerical Value:

1 - Very Severe
2 - Severe
3 - High
4 - Moderate
5 - Slight



LEGEND

——— STATE BOUNDARY
——— COUNTY BOUNDARY
BASIN BOUNDARY
COAL MINING

MAP 18
LAND AFFECTED BY MINING
(1979)
MISSOURI
NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA

SOURCE: Geology and Survey,
Missouri Department of Natural Resources

The remainder of the abandoned land in the Chariton River Subbasin is in Putnam County, about nine miles northeast of Unionville, along Shoal Creek. Most of this abandoned land is small pit operations or underground mining activities. In Adair County, 130 acres of abandoned land were identified in 49 separate locations. These areas ranged from 1 to 15 acres. A similar situation exists in Macon County where 45 abandoned acres have been identified in 13 separate locations. These abandoned coal mines have not been identified as major water quality problems.

Coal mining can be both beneficial and burdensome to a community. The economic and social effects of constructing a coal gasification plant for the Mendota coal region in Sullivan County was investigated by Ahrenholze.* The plant would use 1.4 million tons of coal annually to produce low BTU gas which would be used to produce electricity. Construction of this plant would cause strip mining in Sullivan, Linn, and Putnam Counties. About 1 square mile per year would be strip mined.

*Ahrenholze, James R., The Effects of Coal Related Development on Communities in the Mendota Region: Ph. D. Dissertation, University of Missouri-Columbia, December 1978.

Mining has contributed to the economic growth in the basin but has resulted in the depreciation of water quality and the land base. Streams within the Chariton Subbasin, in particular, have been deteriorated by acidic waters from abandoned mines and the future productivity of land for agriculture has been reduced to almost zero in the mined-over areas. About half of the 13,000 acres depreciated by coal mining was prime agricultural land.

E. Wetlands And Streams (Missouri)

Wetlands—shallow lakes, ponds, marshes, swamps, wet meadows, stream margins, and low areas of flood plains—are a dwindling resource in the basin (Map 13, page 33). Concern for their preservation has increased with people's growing awareness of their importance to the environment.

Most wetlands are extremely productive without help from man. Soils of these natural areas are rich from the nutrients carried to them in surface water runoff from surrounding higher lands. Wetlands rival in plant productivity, the yield of modern agricultural fields which require intensive cultivation and fertilization every year. They serve as floodwater retention areas, natural traps for polluted waters, filters for excess nutrients, and also act as ground water recharge areas.

Wetlands are being destroyed (Table 31) throughout the basin, with most extensive losses occurring along the major rivers in the western third. The costs to offset loss of their natural contributions are increasing.

Two main actions account for the loss of wetlands in the basin. Increased rate of sediment deposition and accelerated land use conversion in bottom lands have contributed to a 70 percent decrease in type 5 wetlands and a 72 percent decrease in type 6 wetlands during the period 1955-1977. A concentrated effort to preserve and manage the basin's remaining wetlands is needed, especially in the western third of the basin.

Stream fishery habitat has not only sustained a loss in quantity, but also a loss in quality. At one time, the Missouri portion of the basin was drained by approximately 10,400 miles of streams. Channelization has decreased these miles in the basin to approximately 9,700. More importantly this loss of 700 miles of stream resources has occurred primarily on perennial streams. In the channelized reaches, stream quality has been lowered by loss of pools, increased stream temperatures, increased streambank erosion, reduction in benthic organisms, and reduction in fish species. These localized adverse effects are compounded by an overall increase in sand bedloads, chemical pollution, and continuance of high suspended sediment loads. Increase in stream nutrients and weak base flows have resulted in an increase of nuisance aquatic plants.

A study of fish distribution during the period 1900-1975 shows four fish species to be possibly extirpated and three species reduced in number (Table 32). Sediment deposition and turbidity levels are probable causes for reduction in fish species and total fish production.

Table 31 -- Wetland Acreage for 28 Missouri Counties, Northern Missouri River Tributaries Basin.

County		Wetland Types 3	4	5	6	Total	Change
		acres					
Adair	1977	0	15	10	0	25	-1,413
	1955	410	125	903	0	1,438	
Andrew	1977	0	15	134	0	149	-1,744
	1955	0	0	213	1,680	1,893	
Atchison	1977	41	60	50	3	154	-5,783
	1955	123	0	374	5,440	5,937	
Buchanan	1977	390	127	1,540	0	2,057	-4,277
	1955	0	200	3,269	2,865	6,334	
Caldwell	1977	0	80	0	0	80	+ 80
	1955	0	0	0	0	0	
Carroll	1977	51	60	0	0	111	- 886
	1955	0	150	822	25	997	
Chariton	1977	6,550	2,405	900	200	10,005	+3,040
	1955	1,700	1,440	3,875	0	7,015	
Clay	1977	125	400	3	0	528	- 19
	1955	7	500	15	25	547	
Clinton	1977	112	26	16	0	154	- 31
	1955	0	0	185	0	185	
Daviess	1977	0	209	855	20	1,084	+ 859
	1955	0	0	95	130	225	
De Kalb	1977	75	0	0	0	75	- 45
	1955	0	0	120	0	120	
Gentry	1977	12	5	62	10	89	- 863
	1955	0	0	98	854	952	
Grundy	1977	0	42	100	0	142	- 999
	1955	0	15	226	900	1,141	
Harrison	1977	0	6	4	0	10	- 23
	1955	0	32	1	0	33	

Table 31 (continued)

County	Year	3	4	5	6	Total	Change
Holt	1977	2,520	715	760	200	4,195	-11,275
	1955	250	520	6,185	8,515	15,470	
Howard	1977	2	110	20	0	132	- 173
	1955	0	190	115	0	305	
Linn	1977	0	0	475	7,500	7,975	+4,975
	1955	3,000	0	0	0	3,000	
Livingston	1977	1,053	61	833	100	2,047	-7,180
	1955	0	65	1,732	7,430	9,227	
Macon	1977	400	100	250	0	750	+ 670
	1955	0	60	20	0	80	
Mercer	1977	0	0	0	0	0	- 786
	1955	0	0	187	599	786	
Nodaway	1977	0	0	0	0	0	-1,755
	1955	0	30	1,725	0	1,755	
Platte	1977	215	410	510	0	1,135	-2,083
	1955	0	205	2,850	163	3,218	
Putnam	1977	80	145	0	0	225	+ 225
	1955	0	0	0	0	0	
Randolph	1977	0	0	30	0	30	- 393
	1955	0	15	408	0	423	
Ray	1977	1,565	1,555	950	0	4,070	+2,679
	1955	150	75	1,106	60	1,391	
Schuyler	1977	0	37	20	52	109	+ 109
	1955	0	0	0	0	0	
Sullivan	1977	5	6	8	3	22	+ 22
	1955	0	0	0	0	0	
Worth	1977	0	0	20	0	20	- 114
	1955	0	1	133	0	134	
TOTALS	1977	13,196	3,589	7,550	8,088	35,423	Net Decrease
	1955	5,640	3,623	24,657	28,686	62,606	-27,183

Table 32 -- Reduction in Fish Species and Numbers of Some Species in Missouri, Northern Missouri River Tributaries to Missouri River, Northern Missouri River Tributaries Basin. (Source: Missouri Department of Natural Resources, 1978 Missouri Water Quality Report)

Stream	Subbasin	Species	Effects to Fish Species (Approximately 58 Species in Region)
Missouri River Tribs.	Tarkio River and Smaller Missouri River Tribs.	Blacknose Shiner Highfin Carpsucker	Two Species Reduced in Number
Nodaway	Nodaway River	Bigmouth Shiner	Increased Numbers Likely Due to Channelization
102 River	Platte River	Common Shiner Topeka Shiner Hornyhead Chub Bigmouth Shiner	Believed Extirpated Believed Extirpated Believed Extirpated Increased Numbers Likely Due to Channelization
Grand River	Upper Grand River	Paddle Fish Blackside Darter	One Species Reduced in Number Believed Extirpated
Chariton River	Chariton River	Paddle Fish	One Species Reduced in Number

F. Wildlife (Missouri)

The key to animal abundance centers around adequate amounts of good quality cover. Carrying capacity of an area for an animal species is a function of natural parameters or properties affecting that animal's abundance — such parameters are vegetative type stands, edge, successional stages, bare ground, land use, water, and distribution.

Results of a small game habitat value study completed in 1978 show the lowest habitat values occur in the western area of the basin. This area has undergone a more rapid land use change over the past 40 years than the remainder of the basin. These rapid changes resulted in a steady decline of both habitat diversity and interspersion of cover types (Table 33).

Increased availability of waste grain, conversion of grasslands to head grains, increase in rough/idle areas, smaller fields providing more edge, and increases in woody cover helped hold wildlife habitat values at levels known to support good game populations.

LAND CLEARING

Woody cover clearing lowers habitat values.

Table 33 -- Upland Habitat Trends in Missouri, Northern Missouri River Tributaries Basin.

SAMPLE AREAS	AVERAGE VALUES PER MILE OF TRANSECT		PERCENT CHANGE
Andrew	1939	1974	
H.D.I.*	11.4	9.2	- 19
I.I.	73.0	52.0	- 29
V.I.F.	74.0	46.0	- 38
V.I.W.	0.04	0.04	0
E.I.	30.3	28.0	- 8
Caldwell	1940	1970	
H.D.I.	8.8	10.4	+ 18
I.I.	50.4	60.3	+ 20
V.I.F.	36.0	44.4	+ 23
V.I.W.	0.4	1.2	+200
E.I.	22.7	31.6	+ 39
Carroll	1939	1970	
H.D.I.	5.0	4.7	- 6
I.I.	27.0	28.0	+ 4
V.I.F.	33.0	29.0	- 13
V.I.W.	0.1	0.4	+100
E.I.	8.0	6.6	- 18
Chariton	1940	1970	
H.D.I.	7.0	6.0	- 14
I.I.	31.0	26.0	- 16
V.I.F.	20.6	28.4	+ 38
V.I.W.	1.8	6.0	+233
E.I.	13.1	14.0	+ 7
Daviess	1940	1973	
H.D.I.	10.5	12.0	+ 14
I.I.	45.4	35.0	- 23
V.I.F.	39.8	27.0	- 32
V.I.W.	2.7	3.6	+ 33
E.I.	16.4	26.1	+ 59

* Definitions follow

Table 33 (continued)

SAMPLE AREAS	AVERAGE VALUES PER MILE OF TRANSECT		PERCENT CHANGE
Holt #1	1940	1974	
H.D.I.	11.0	8.6	- 22
I.I.	72.0	58.0	- 26
V.I.F.	67.0	48.0	- 29
V.I.W.	0.4	0.4	0
E.I.	28.2	27.6	- 2
Linn	1939	1970	
H.D.I.	8.7	10.5	+ 21
I.I.	45.0	27.0	- 40
V.I.F.	46.4	51.0	+ 10
V.I.W.	10.4	11.0	+ 6
E.I.	22.2	31.8	+ 43

* Habitat Diversity Index (H.D.I.) - As used in the Missouri Habitat Studies, the Habitat Diversity Index is a figure reflecting the number of vegetative type - edge type changes encountered per mile of transect study. A value of 10 or higher is typical of upland wildlife habitat.

Interspersion Index (I.I.) - The average numerical value of parameter(s) per transect mile x the H.D.I. A value of 40 indicates a richness in terms of food and cover interspersion.

Vegetative Index of Fields (V.I.F.) - Reflects the numerical rating value for wildlife (quail) of growing crops, grasslands, rough and odd areas. A value derived from the average numerical field value of the parameter(s) per transect mile x the H.D.I. of the parameter per transect mile. A value of 40 reflects an acceptable quality of habitat.

Vegetative Index of Woodlands (V.I.W.) - Reflects the numerical rating value for wildlife (quail) of woodland tracts. A value derived from the average numerical value of woodland crown closure game values per transect mile x the H.D.I. of the parameter per transect mile. A value of one or greater is high quality woodland for small game.

Edge Index (E.I.) - Reflects the numerical rating value for wildlife (quail) of edge-lands. A value derived from the average numerical value of the edge parameter(s) per transect mile x the H.D.I. of the parameter(s) per transect mile. A value of 30 is a suitable habitat condition..

Low wildlife habitat values are caused by conversion of woody cover to create larger fields, conversion of corn and wheat to soybeans, reduction in grass-legume mixes, increase in cattle and grazing intensity, clean-till cultivation, intensive row crop rotations, one species grass (fescue) pastures, reduced use of Korean lespedeza, and woodland grazing. Woody cover clearing has also lowered habitat values. Large, clean-tilled soybean fields leave little to attract wildlife.

ROW CROP

Large clean-tilled soybean fields offer little to improve habitat values.

Reduction of corn/wheat acreage, which were favorable field types for wildlife under early day agricultural practices, and the increase in soybean production may be one of the most significant factors in habitat value declines. The present clean-till soybean field surrounded or joined by fescue grasslands does not measure up to the wildlife values possessed by the old-time weed infested cornfield.

The greatest losses of habitat values have occurred in the western third of the basin. The remainder of the basin still maintains areas of good habitat values, but at reduced levels from the past. Preservation and management of existing habitat in the eastern two-thirds of the basin is needed. The western third needs an intensive program of habitat development and management to achieve improved wildlife habitat values.

Increased urban pressure has also taken its toll on high quality wildlife habitat. Subdivisions, highways, shopping centers, etc., all require land; removing much of it from wildlife production.

G. Water Supply (Missouri)

Water supply problems involve seasonal supply shortages, inadequate local sources, inferior quality and inadequate facilities for storage, treatment and distribution. As a result, some rural areas have seasonal or annual shortages of water for domestic, industrial, or agricultural use.

Seasonal supply shortages for 24 reservoirs were checked (Table 34). Of the 24 reservoirs checked, 15 (underlined on table) show a projected deficiency. The projected average consumption is the projected watershed deficiency yield (based upon a 2 percent occurrence) in the year 2000.

H. Flooding

Current average annual agricultural floodwater damages of $32.3 million were identified (Table 35). Floodwater damages identified in this section were computed for the evaluated flood plain. The evaluated flood plain is a smaller area than the total flood plain discussed under bottom land problems, page 53. Flood prone areas along the major tributaries are predominantly agricultural. Damage to crops and pasture accounts for 79 percent of the total damages. Average crop yields for the year 1970 to 1974 and current normal prices of October 1976 were used in the damage appraisal.

Table 35 -- Average Annual Floodwater Damages, Present Conditions, 1970-1974, Northern Missouri River Tributaries Basin, Iowa and Missouri

Item	Average Annual Floodwater Damages (1,000 dollars)	(Percent)
Crop and Pasture	25,637	79.3
Other Agricultural	1,396	4.3
Land Damages	714	2.2
Road and Bridge	1,707	5.3
Other	2,887	8.9
	32,341	100.0
Flood Plain Acres	1,070,740	

The basin area, of 11.9 million acres, consists of 79 percent upland and 21 percent bottom land. Total bottom land, including the Missouri River bottom lands, is 2,491,700 acres. Not all are subject to flooding. Flood prone acres identified in this study were confined to the major tributaries to the Missouri River and did not include the Missouri River bottom lands. The total flood plain evaluated was 1,070,740 acres or 43 percent of the total bottom land (Table 36).

Table 34 -- Carryover Storage Requirements for 24 Reservoirs in Missouri, Northern Missouri River Tributaries Basin.

Location	Reservoir Storage (100 Ac Ft per Sq Mi)	Av. Yield (Runoff Inches)	2% Chance of Deficiency			Av. MGD Usage	
			CFS/S.M.[1/]	CFS[2/]	MGD[3/]	1977	2000
N.W. Mo. Regional P.C.							
King City	.346	6.2	.26	.224	.145	.100	.119
Mo-Kan Regional P.C.							
Cameron	.251	6.8	.23	1.129	.730	.400	.592
Gower	.293	6.6	.24	.072	.046	.130	.156
Maysville	.034	6.5	.04	.130	.084	.140	.167
Savannah	.102	6.1	.13	.111	.071	.407	.604
Mid America Regional P.C.							
Dearborne	.041	6.6	.05	.028	.018	.055	.102
Green Hills Regional P.C.							
Bethany	.914	6.5	.38	.566	.365	.390	.580
Breckenridge	.100	7.2	.13	.085	.055	.020	.024
Brookfield	1.484	8.0	.53	.567	.366	.540	.799
Bucklin	.147	8.2	.18	.101	.066	.058	.069
Green City	.305	7.6	.28	.026	.016	.066	.079
Hamilton	.007	6.9	.02	.037	.024	.130	.192
Harrison PWSD #1	.003	6.3	.01	.049	.031	.075	.091
Jamesport	.046	7.2	.08	.150	.097	.051	.060
Linneus	.192	8.0	.22	.160	.103	.043	.051
Mercer	.015	6.6	.03	.044	.028	.025	.029
Ridgeway	.046	6.5	.07	.009	.005	.012	.014
Unionville	.154	7.0	.16	.458	.296	.307	.455
N.E. Mo. Regional P.C.							
Downing	.197	7.1	.20	.068	.044	.023	.027
Schuyler PWSD #1	.173	7.1	.19	.167	.108	.079	.096
Mark Twain Regional P.C.							
Atlanta	.412	7.8	.33	.092	.059	.018	.021
LaPlata	.138	7.6	.16	.100	.064	.130	.155
New Cambria	.301	8.2	.29	.050	.032	.026	.031
Higbee	.432	9.0	.37	.059	.038	.053	.063

1/ Cubic feet per-second per square mile
2/ Cubic feet per second
3/ Million gallons per day (underlined figures denote demand exceeding supply for a 2% chance of deficiency)

Table 36 -- Average Annual Floodwater Damages by Hydrologic Units, Present Conditions 1970-1974, Northern Missouri River Tributaries Basin, Iowa and Missouri

Hydrologic Unit Code	Subbasin	Drainage Area	Evaluated Flood Plain	Crop and Pasture	Other Agric.	Sediment Swamping Scour	Road and Bridge	Other**	Total Damage
		Sq. Mi.	Acres	dollars in thousands					
10240005	Tarkio	1,368	40,370	685.1	38.7	3.2	36.9	76.4	840.3
10240009	U. Nodaway	813	45,530	535.9	49.0		49.0	63.4	697.3
10240010	Nodaway	1,007	60,730	1,015.3	70.6	41.5	50.6	117.8	1,295.8
	Total	1,820	106,260	1,551.2	119.6	41.5	99.6	181.2	1,993.1
10240011	Direct Tribs.*	399							
10240012	Platte	1,678	72,620	732.3	45.9	64.9	88.6	93.1	1,024.8
10240013	102 River	741	44,680	760.8	42.1	85.7	60.1	94.8	1,043.5
	Total	2,419	117,300	1,493.1	88.0	150.6	148.7	187.9	2,068.3
10280101	U. Grand	3,267	216,260	5,436.7	293.4	130.6	443.0	571.8	6,875.5
10280102	Thompson	2,205	137,800	2,634.5	164.8	146.8	209.2	315.6	3,470.9
10280103	L. Grand	2,408	222,380	8,376.1	418.8	120.1	345.5	926.1	10,186.6
	Total	7,880	576,440	16,447.3	877.0	397.5	997.7	1,813.5	20,533.0
10280201	U. Chariton	1,346	30,360	705.8	35.3	30.1	46.1	81.7	899.0
10280202	Chariton	1,033	106,890	1,737.2	86.8	91.3	111.6	202.7	2,229.6
10280203	Little Chariton	704	43,440	1,386.2	69.3	--	108.1	156.4	1,720.0
	Total	3,083	180,690	3,829.2	191.4	121.4	265.8	440.8	4,848.6
1030101	Direct Tribs.	1,570	49,680	1,631.4	81.6		157.9	187.1	2,058.0
	Total Basin	18,539	1,070,740	25,637.3	1,396.3	714.2	1,706.6	2,886.9	32,341.3

Price base: Current normalized for agriculture (Oct. 1976 WRC). 1970-1974 crop yields.

* Not evaluated

** Certain losses resulting from flooding even though the property involved is not flooded.

The 18,539 square mile basin is divided into 13 hydrologic unit areas (Map 19). The study area in Southern Iowa and Northwestern Missouri includes the hydrologic areas of the Tarkio, Nodaway, Platte, Grand and Chariton Rivers. It also includes the minor direct tributaries north of the Missouri River between the outlets of the Nishnabotna River and Little Chariton River.

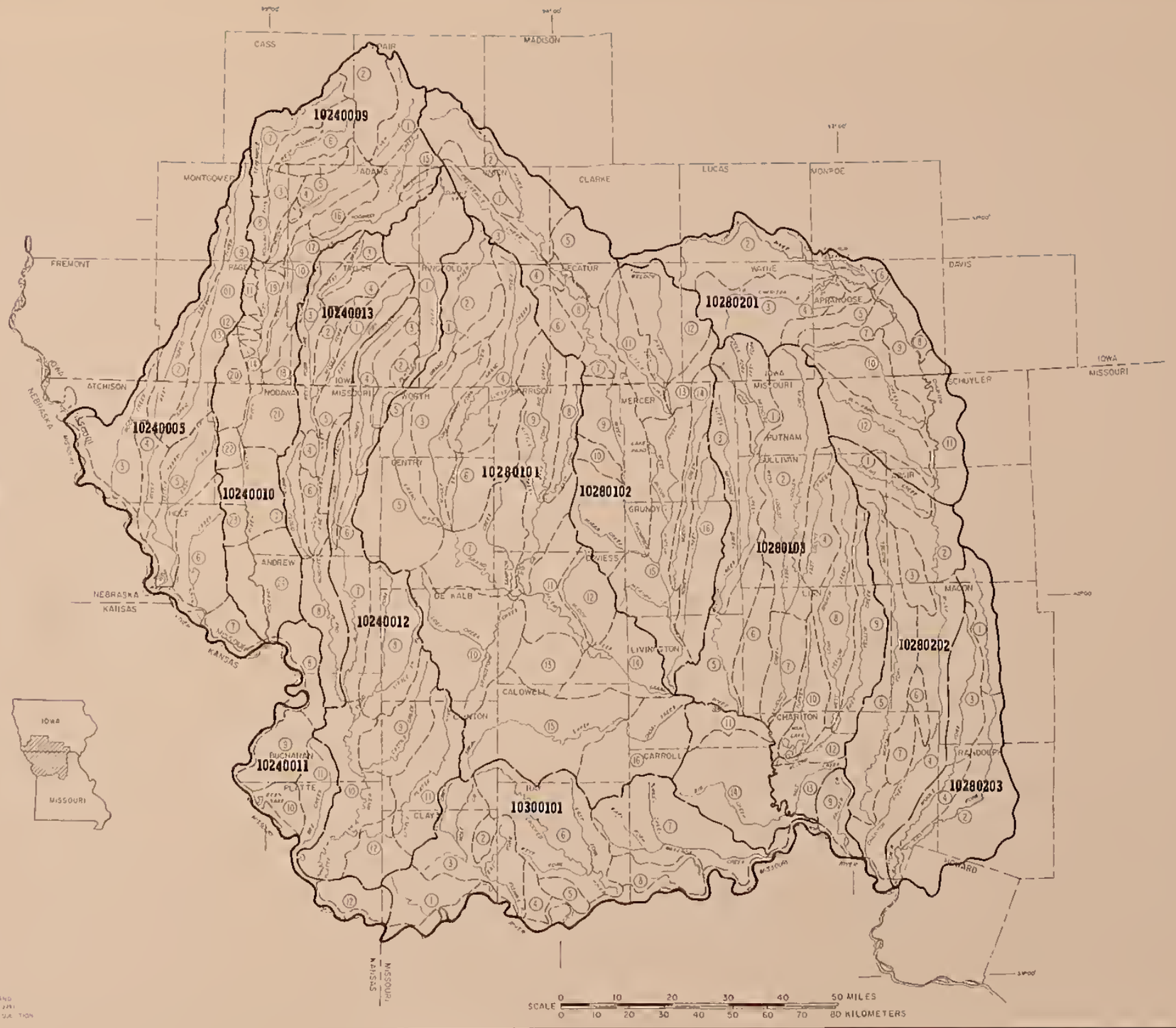
Most flood damages occur during the growing and harvesting seasons. Data from stream gages in the basin show the following storm distribution.

Season	Months	Percent Storm Distribution
Spring	March, April, May	32
Summer	June, July, August	39
Autumn	September, October, November	21
Winter	December, January, February	8

Crop damage occurs as yield reduction. The intensity of crop damage is largely dependent on the depth and duration of flooding. Additional costs are incurred from reseeding, additional tillage operations, additional fertilizer, insecticides and herbicides.

Cropland Flooding.
South of Tina, Missouri
June 9, 1982

U S DEPARTMENT OF AGRICULTURE



LEGEND

- STATE BOUNDARY
- COUNTY BOUNDARY
- DRAINAGE
- LAKES
- BASIN BOUNDARY
- SUBBASIN BOUNDARY
- WATERSHED BOUNDARY
- 10280202 HYDROLOGIC UNIT CODE
- (10) WATERSHED NUMBER

MAP 19

WATERSHED AND HYDROLOGIC UNIT MAP

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

MISSOURI AND IOWA

REV 2-21-80
S,R-35,0554

Flood plain land use is expected to continue to be predominantly cropland. The flood plain consists of 79 percent cropland, 7 percent pastureland, 11 percent forest land, and 3 percent other land.

The principal crops grown on the flood plain are corn (38 percent), soybeans (40 percent), wheat (6 percent), and rotation hay and pasture (16 percent).

Sediment, erosion, and swamping damages are estimated to be $714,200 annually. Sediment damages were identified on 33,170 acres, swamping on 2,260 acres, and scour on 12,900 acres. Sediment damages associated with growing plants on 19,940 acres were identified as agronomic sediment damage.

Road and bridge damages are estimated to be $157,900 annually. Road and bridge damages were based on the number and type of road crossings in the flood plain and frequency of flooding. Other damages were estimated at 10 percent of all direct damage.

Urban Flooding
Carrollton, Missouri.
June 10, 1982

Although not comprehensively evaluated, urban flooding is a problem in the Northern Missouri River Tributaries Basin.

A comparison of floodwater damages in the eight subbasins is provided in Table 37. Damages, expressed in dollars per square mile of drainage area and dollars per flood plain acre, are only for the evaluated flood plain.

Table 37 -- Comparison of Average Annual Floodwater Damages by Subbasins, Northern Missouri River Tributaries Basin, Iowa and Missouri

Subbasin	Drainage Area		Av. An. Floodwater Damage*	
	Total Sq. Mi.	Evaluated Sq. Mi.	Dollars Per Sq. Mi.	Dollars Per F.P. Acre
Tarkio	1368	901	932	21
Nodaway	1820	1598	1247	19
Platte	2419	2390	865	18
Direct Tribs.	1570	994	2071	41
Upper Grand	3267	3267	2103	31
Thompson	2205	1917	1811	25
Lower Grand	2408	2408	4230	46
Chariton	3083	2176	2228	27

*Present condition 1970-74

The Lower Grand Subbasin has the highest damages with $4,230 per square mile or $46 per flood plain acre accruing annually. Most of the major stream channels in the Lower Grand Subbasin are filling. More than once per year, 87 percent of the flood plain is flooded.

Detailed data for the 13 hydrologic unit areas as designated by the Water Resources Council is available in eight subbasin inventory and analysis reports (listed on pages xii and xiii). These include tabular data by evaluation reaches on such items as damages, land use, frequency, flood plain acres, and drainage areas.

Appendix A contains a brief summary of floodwater problems in each of the eight subbasins.

I. Recreation (Missouri)

Recreational problems can be described as facility deficiencies. In 1975, only four categories had a sufficient supply of recreational facilities. This supply will be reduced further by 1990 when only three activities; boating, lake swimming, and golf; will have a sufficient supply.

Basin wide, there are 6 of 20 activities showing a major need for development (Table 38).

Table 38 -- Missouri Recreational Needs (1976, SCORP, MO) Basin Wide, Northern Missouri River Tributaries Basin.

Activities	Unit	1975	1990
Camping	Sites	4,846	9,493
Lake Fishing	Acres	9,395	74,981
Launch Ramps	Ramps	311	597
Swimming Pools	Sq. Ft.	4,800	11,700
Picnicking	Tables	4,786	11,233
Hunting	Acres	134,242	261,932

Individual regional analysis show varied needs for the six activities (Tables 39-42). While some regional areas (Map 12, page 29) are consistent with the basin needs, others show an idle capacity; both in 1975 and 1990.

Table 39 -- Missouri Recreational Needs (1976 SCORP, MO), Northwest Missouri Region, Northern Missouri River Tributaries Basin.

Activities	Unit	1975	1990
Camping	Sites	58	141
Lake Fishing	Acres	120 I	30
Launch Ramps	Ramps	1 I	1
Picnicking	Tables	30	260
Hunting	Acres	14,700	25,100

I = Idle Capacity

Table 40 -- Missouri Recreational Needs (1976 SCORP, MO), MO-KS Bi-State Region, Northern Missouri River Tributaries Basin.

Activities	Unit	1975	1990
Camping	Sites	440	650
Lake Fishing	Acres	2,300	4,890
Launch Ramps	Ramps	20	44
Swimming Pools	Sq. Ft.	31,600	108,300
Picnicking	Tables	320 I	240
Hunting	Acres	10,800	24,500

I = Idle Capacity

Table 41 -- Missouri Recreational Needs (1976 SCORP, MO), Green Hills Region, Northern Missouri River Tributaries Basin.

Activities	Unit	1975	1990
Camping	Sites	300	590
Lake Fishing	Acres	830	3,030
Launch Ramps	Ramps	70	40
Swimming Pools	Sq. Ft.	12,800 I	16,400
Picnicking	Tables	190	730
Hunting	Acres	18,600	42,500

I = Idle Capacity

Table 42 -- Missouri Recreational Needs (1976 SCORP, MO), Mid-America Region, Northern Missouri River Tributaries Basin.

Activities	Unit	1975	1990
Camping	Sites	4,020	7,660
Lake Fishing	Acres	9,300	68,400
Launch Ramps	Ramps	260	490
Swimming Pools	Sq. Ft.	483,200	1,028,300
Picnicking	Tables	4,950	9,870
Hunting	Acres	8,900	162,300

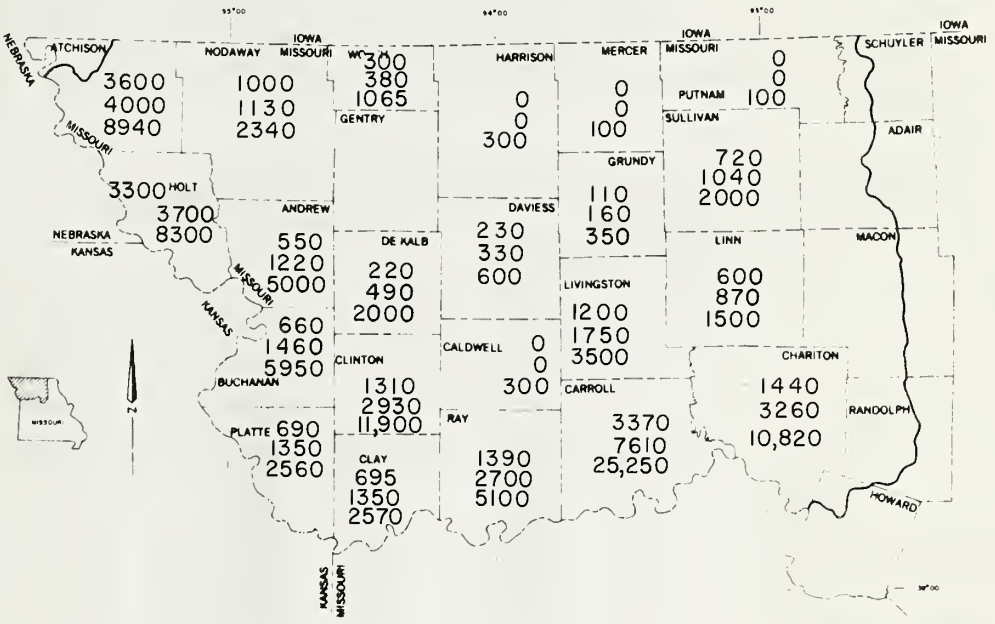
In 1978, the Missouri Department of Natural Resources conducted a stream evaluation of selected stream segments in the Missouri portion of the basin. The study showed that canoeing offers the most promise for stream related recreation activities. However, canoeing is generally best at high flows and stream accesses are limited.

J. Irrigation (Missouri)

Irrigation has been considered marginal and has not been extensively practiced. Supplemental irrigation is normally beneficial and usage is on the increase. Normally, evapotranspiration exceeds rainfall from mid-June through August. Irrigation can enhance and stabilize agricultural production. Irrigation equipment dealerships are increasing, particularly in the Missouri River alluvium

areas. Irrigation development is primarily by individuals; group projects have little acceptance.

The major problems associated with irrigation in Missouri is water supply. The most dependable water supply sources are surface impoundments and the Missouri River alluvium. The Missouri River alluvium has not, as yet, been overtapped as a water source. The irrigated area along the Missouri River is estimated to increase from 15,135 acres in 1977 to 23,200 acres in 1985, and by the year 2000 to 60,300 acres (Map 28). An 8-inch average annual irrigation, assuming 70 percent distribution efficiency, would require 14,400 acre-feet of water in 1977, 22,100 acre-feet in 1985, and 57,400 acre-feet in 2000.



LEGEND
——— STATE BOUNDARY
——— COUNTY BOUNDARY
~~~ BASIN BOUNDARY
TOP NUMBER – 1977
MIDDLE NUMBER – 1985
BOTTOM NUMBER – 2000

MAP 28
IRRIGATED ACRES
BY TIME PERIOD
MISSOURI

NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA

For areas outside the Missouri River alluvium, an estimated 6,250 acres were irrigated in 1977, 12,800 acres are expected to be irrigated in 1985, and 43,885 acres in year 2000. A dependable water supply source for this area can be surface impoundments. Assumptions used in calculating water supply needed in impoundments to serve irrigated acres were: 8-inch irrigation application at 70 percent distribution efficiency and an increase in reservoir storage of 50 percent to account for evaporation, seepage, and dry years. The calculated impoundment needs are 8,730 acre-feet for 1977, 18,400 acre-feet for 1985, and 62,700 acre-feet for the year 2000.
~~~

The potential for irrigation is 843,600 acres in the Missouri River alluvium and an additional 4,511,400 acres scattered throughout the basin. An estimated 7,740,000 acre-feet of water annually would be required to irrigate this combined acreage of 5,355,000 acres.

K. Missouri River Flood Plain Drainage Systems

The objective of this study was to identify areas of the Missouri River bottom land having wetness or drainage problems. The problem may be increased by submergence of drainage outlets during high flow elevations in the Missouri River. Major levels of concern are those flow levels maintained for navigation.

In 1974, the Missouri River was lower during the navigation season than normal; it approached the minimum navigation level. Elevations were established along the river on July 16, 1974. Based on this profile, 7,100 acres are less than five feet above the water level. Table 43 shows the area affected based on this profile.

Table 43 -- Area of Bottom Land Affected by July 16, 1974, Missouri Water Level, Northern Missouri River Tributaries Basin.

	Distance above Mo. River Profile in Feet			Area of Mo. River Bottom Land in Study Area	Percent of Total Bottom Land Less Than 5 feet Above Profile
	0-3	3-5	Total		
	----------Acres----------				
Holt Co. below Hwy. 159	400	800	1200	42800	2.8
Andrew County	0	0	0	7220	0
Buchanan County	0	200	200	43670	0.5
Platte County	300	900	1200	33380	3.6
Clay County	0	0	0	28670	0
Ray County	500	2600	3100	86200	3.6
Carroll County	300	1100	1400	123900	1.1
Total	1500	5600	7100	365840	1.9

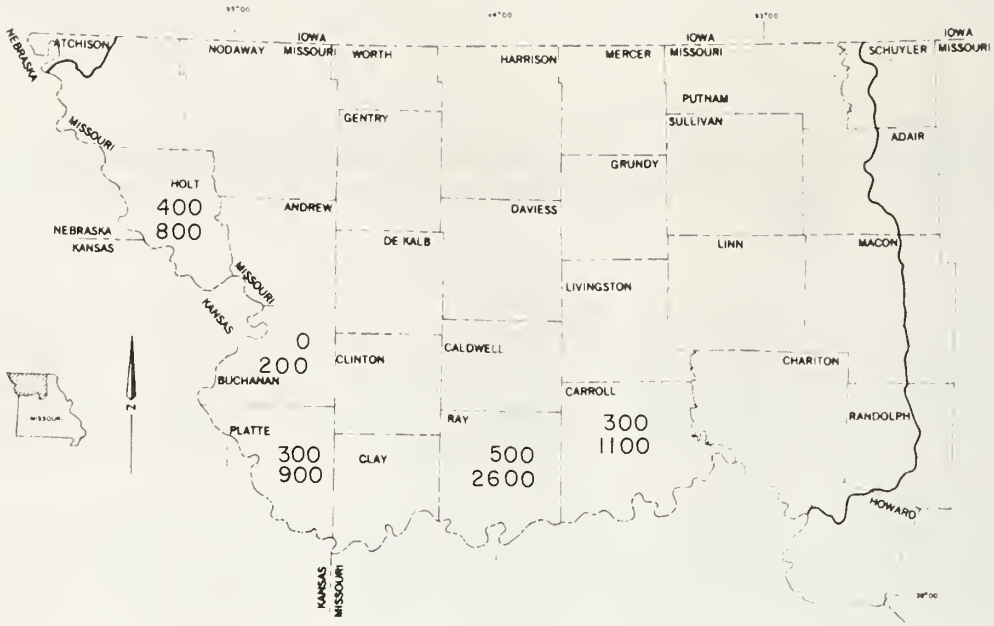
In 1975, the Missouri River carried more water and stayed higher than average for the entire season. Elevations were established along the river August 6, 1975. Based on this profile, 40,100 acres are less than five feet above the water level. Table 44 shows the area affected, based on this profile.

Table 44 -- Area of Bottom Land Affected by August 6, 1975, Missouri River Water Level, Northern Missouri River Tributaries Basin.

	Distance Above Mo. River Profile in Feet			Total	Area of Mo. River Bottom Land in Study Area	Percent of Total Bottom Land Less Than 5 Feet Above Profile
	0-1	1-3	3-5			
	Acres					
Holt Co. below Hwy. 159	1500	4100	6400	12000	42800	28.0
Andrew County	0	200	200	400	7220	5.5
Buchanan County	700	2500	2900	6100	43670	14.0
Platte County	500	1600	2300	4400	33380	13.2
Clay County	0	0	100	100	28670	0.3
Ray County	2100	4600	5900	12600	86200	14.6
Carroll County	1000	1100	2400	4500	123900	3.6
Total	5800	14100	20200	40100	365840	11.0

The areas affected by the two profiles are shown on Maps 29 and 30. These maps show location of areas by increments of 0 to 3 feet and 3 to 5 feet above Missouri River profile for the July 16, 1974, and August 6, 1975, water levels.

In most cases, particularly the lower lying areas, the only effective method of removing the excess water is by installation of pumping plants.



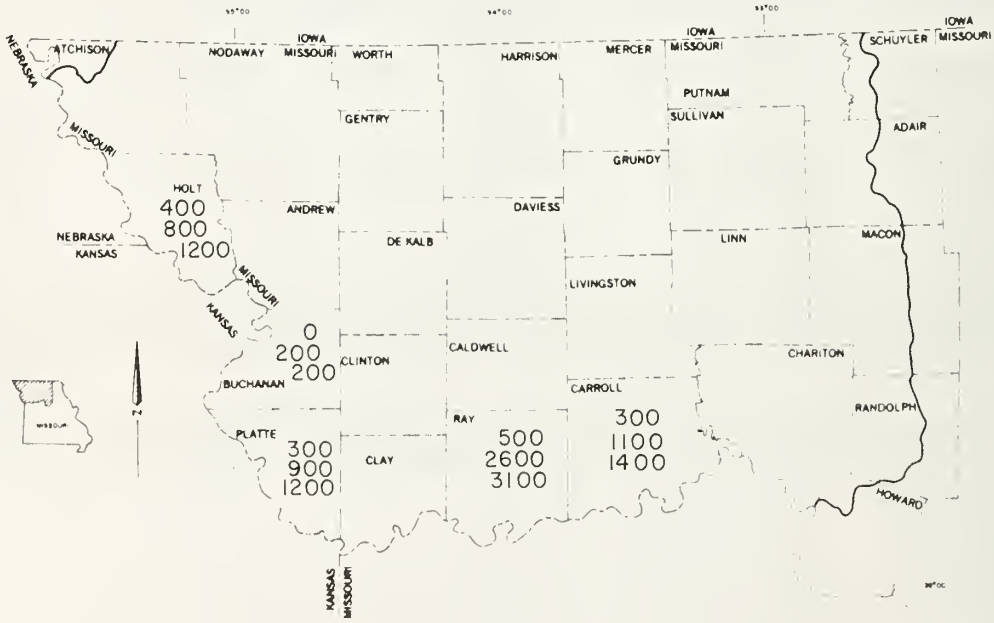
LEGEND

——— STATE BOUNDARY
——— COUNTY BOUNDARY
~~~ BASIN BOUNDARY

TOP NUMBER 0-3FT. ABOVE PROFILE
BOTTOM NUMBER 3-5FT. ABOVE PROFILE

MAP 29
AREA OF BOTTOM LAND
EFFECTED JUL. 16, 1974
43,500 CFS AT KANSAS CITY, MO.
MISSOURI

NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA



LEGEND

——— STATE BOUNDARY
——— COUNTY BOUNDARY
~~~ BASIN BOUNDARY

TOP NUMBER 0-1FT. ABOVE PROFILE
MIDDLE NUMBER 1-3FT. ABOVE PROFILE
BOTTOM NUMBER 3-5FT. ABOVE PROFILE

MAP 30
AREA OF BOTTOM LAND
EFFECTED AUG. 6, 1975
67,300 CFS AT KANSAS CITY, MO.
MISSOURI

NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA

CHAPTER III

CONCLUSIONS AND RECOMMENDATIONS

III. Conclusions and Recommendations

This study has shown that the major land and water resource problem in the basin is the irreversible losses in the productive capability of the soil resource due to erosion and the increasing number of acres that are affected. In order to solve this problem, we must first understand the Whys and Hows (reason) and then the Whats (magnitude) and Whens (time period).

The basin is one of the major agricultural producing areas in the state. The basin, which includes 20 percent of the state area, produces approximately 40 percent of the corn, 15 percent of the wheat, 30 percent of the soybeans, and 15 percent of the sorghum grown in the State of Missouri. Basin acreages for these crops have increased from 2.2 million in 1970 to 3.2 million in 1979 (45 percent increase). Refer to Table 45. Most of this increase in tilled cropland has come about through the conversion of rolling grassland. This major change in land use will continue to significantly increase the rate of erosion, sedimentation, and runoff peaks in the basin. One of the most alarming concerns about this change is the 1-million-acre increase in soybeans, which leaves little residue for erosion control.

The demands for increased agricultural production is expected to continue. The Agricultural Land Committee presented in their report a projection of the major crop needs according to OBERS for the State of Missouri. A comparison of production, yields, and acreage for projected years of 1985, 2000, and 2020 to similar data for a base period of 1970 through 1974 is displayed in Table 46. Actual harvested data for 1978 and 1979 is also shown in Table 46. A comparison of the 1978 and 1979 data indicates that present production exceeded or are approaching 1985 projections. Projections for the year 2000 show an increase of 3 million acres of tilled cropland in the State and appear to be very realistic. Based on a proportionate share of the State's productive soils being in the basin, it is estimated that the basin's tilled cropland will increase by at least 1 million acres by the year 2000.

A review of Cropland Distribution by Soil Capability Class (Table 47) indicates that most of the increase in tilled cropland will occur in the upland. Only about one-third of upland (Capability Class I thru IV) is now used for tilled cropland. Nearly two-thirds of the bottom land is used for tilled cropland. The maximum potential use of bottom land for cropland is usually limited to 80 percent due to timber corridors along streams and isolated areas. Less than 400,000 acres of bottom land are available for conversion. Therefore, at least 60 percent of the 1-million-acre increase in tilled cropland by year 2000 will occur in the upland. The increase in tilled upland will increase flood peaks, gross erosion, and sedimentation. This will also lower water quality and degrade wildlife habitat. The bottom lands have serious flooding problems with present conditions. More frequent flooding, along with the high cost of production, could create an economic risk which would cause abandonment of bottom land as cropland. This could significantly increase the demand for more production from the rolling uplands which would have a chain reaction of increasing flooding and erosion problems. The bottom lands are presently producing 40 percent of the row and small grain crops. Therefore, it is essential to maintain this area as cropland.

A. Land Use Conflicts

The basin is predominantly rural. The population around Kansas City (Clay and Platte Counties) is projected to increase about 30 percent by the year 2000. Population in the other counties is projected to remain constant with

Table 45 -- Crop History for Northern Missouri River Tributaries Basin, Missouri[1/]

(24 Counties)

	Corn Ac.	Wheat Ac.	Soybeans Ac.	Sorghum Ac.	Total Ac.
1970	1,090,000	146,000	910,000	51,700	2,197,700
1971	1,161,000	112,800	952,000	105,900	2,331,700
1972	977,000	102,100	1,126,000	76,300	2,281,400
1973	1,097,100	110,000	1,253,000	57,700	2,517,800
1974	1,163,700	163,000	1,192,400	44,700	2,563,800
Ave. 1970-74	1,097,760	126,780	1,086,680	67,270	2,378,490
1975	1,137,000	267,700	1,239,200	79,250	2,723,150
1976	1,132,000	354,300	1,079,200	107,300	2,672,800
1977	1.110,800	348,000	1,373,400	194,600	3,026,800
1978	851,800	84,250	1,672,200	179,600	2,787,850
1979	885,300	305,200	1,909,200	132,600	3,232,300
Ave. 1975-79	1,023,380	271,890	1,454,640	138,670	2,888,580
% change 1975-79 from 1970-74	-7%	+114%	+34%	+106%	+21%
% change 1970 to 1979	-19%	+109%	+110%	+156%	+47%
		Statewide Acreage			
Ave. 1970-74	2,687,000	943,000	3,996,000	434,600	8,061,000
Basin % of State	40.8%	13.4%	27.2%	15.5%	29.5%

1/ Harvested data from Missouri Farm Facts, ESS and Mo. Dept. of Agr.

Table 46 -- Comparison of Agricultural Production Projections and Actual Production, Missouri - Statewide

Crop	Item	1970-1974 Average Base Period	Projected Year 1/			Actual Harvested	
			1985	2000	2020	1978	1979
Corn	1000 Bu.	210,101	275,616	358,675	402,982	191,400	228,660
	Bu./Ac.	76.5	92.1	108.1	124.0	87	103
	1000 Ac.	2,746	2,992	3,318	3,250	2,200	2,220
Sorghum	1000 Bu.	28,149	44,000	59,345	76,272	68,000	59,040
	Bu./Ac.	65.8	88.8	108.5	128.2	80	82
	1000 Ac.	427	495	546	595	850	720
Soybeans	1000 Bu.	103,004	184,717	276,847	311,143	157,890	186,795
	Bu./Ac.	27.5	30.6	34.1	37.7	28.5	31.5
	1000 Ac.	3,746	6,036	8,119	8,253	5,540	5,930
Wheat	1000 Bu.	48,000	54,508	59,737	62,345	28,560	70,400
	Bu./Ac.	34.5	41.3	46.8	52.5	34	44
	1000 Ac.	1,391	1,320	1,276	1,188	840	1,600
Total	1000 Ac.	8,310	10,843	13,259	13,286	9,430	10,470
Percent of 1970-74 Base period			130%	159%	160%	113%	126%

1/ Projected production and yield from OBERS.

Table 47 -- 1978 Cropland Distribution by Soil Capability Class for Northern Missouri River Tributaries Basin, Missouri[1/]

	Total Area	Cropland CNI [2/]		Tilled CNI Cropland [3/]	
		Acres	%	Acres	%
Upland Capability Class I, II, and III	3,634,901	2,650,775	73	1,434,929	39
Upland Capability Class IV	1,130,201	752,372	67	346,999	31
Upland Capability Class VI and VII	1,550,457	475,185	31	152,543	10
Bottom Land Capability Class I, II, and III	1,847,012	1,344,089	73	1,094,043	59
TOTAL	8,162,471	5,222,421	64	3,028,514	37

1/ The acreages shown in this table are adjusted to reflect 1978 production (Missouri Crop and Livestock Reporting Service) using the same percentage of crop distribution of soils by capability class in 1967 CNI. The 1977 NRI for state total figures showed a change in cropland occurred uniformly in all capability classes.

2/ The Conservation Needs Inventory 1967 (CNI) definition of cropland included alfalfa, hayland, cropland, pasture, and idle. These lands usually remain in this use and are not used in rotation with other crops. (Table 3-Agricultural Land Work Group)

3/ Tilled cropland is defined as row crops and small grain and are usually tilled annually. (Table 3-Agricultural Land Work Group)

some shift from rural areas to towns. Therefore, the only major conflict between prime farmland and development is expected to occur in Platte and Clay Counties. In a 10 year period (1964-1974) 41,000 acres of agriculture were used for development. The soil survey shows 33 percent of Platte County and 25 percent of Clay County as prime or potential prime farmland. The alluvial soils comprise 23 percent and 14 percent, respectively, of Platte and Clay Counties. Twenty of 27 counties have modern soils information or are in the process of developing soil surveys. The impact on prime farmland could be significantly reduced by controlling development through zoning based on detailed soil maps.

Recommendations

1. Zoning commissions should take stronger action to preserve prime farmland based on detailed soil survey maps.

2. Priority should be given to completing soil surveys in eight counties that do not have soil surveys underway.

B. Erosion

Severe erosion has occurred over much of the area for over 140 years and over one-half of the topsoil has been removed. This is particularly true in the Grand and Chariton Basins where the loess topsoil was originally 12 to 16 inches deep. The remaining topsoil is critical to maintaining crop production as the clay subsoils have slow infiltration rates and less available water-holding capacity. Sheet erosion on tilled upland is the most critical erosion problem. The average annual rate of erosion on tilled upland ranges from 30 tons per acre in Nodaway, Chariton, and Tarkio to 20 tons per acre in the other subbasins. At these rates, 1 inch of topsoil is removed in about 5 and 7½ years, respectively. However, erosion in the eastern two-thirds of the basin is a more serious resource problem, as the loss of its thin loess cap would be severely limiting to this area as a producer of food and fiber. The 1-million-acre increase in tilled cropland during the 1970's has magnified the erosion problem in the basin as much of this new cropland increase was on steep rolling topography. This trend in land use change is expected to continue and will seriously increase erosion and sedimentation in the basin unless adequate protection measures are applied.

Gully erosion is active in the basin. Generally, gullies develop most rapidly on slopes used for crops and in areas where runoff is concentrated. Gullies are more severe where deep loess soils are present. In many places channel straightening has resulted in valley trenching and subsequent accelerated gully erosion.

Gullies (1) void or cause land loss, (2) depreciate adjoining lands, (3) threaten existing water management systems, (4) act as disincentive for the installation of needed erosion control measures, and (5) produce sediment. Based on detailed studies in the West Fork of Big Creek Watershed, gully erosion over a 100-year evaluation period would be expected to destroy 3 percent of the basin lands, to depreciate 25 percent of the basin lands, and to produce 12 percent of the basin's sediment.

A SHEET EROSION EFFECT

Continued deterioration of the soil resource by erosion is the most serious resource problem in the basin. This problem must be solved in order to maintain food and fiber production fur future generations (Harrison County, Missouri).

AN ALTERNATIVE--NO-TILL PLANTING

No-till planting is an alternative to conserving soil, the basin's most valuable resource (Randolph County, Missouri).

Control of gullies is basic to long-term solutions of upland erosion problems. Sheet and gully erosion is an interrelated problem that is rapidly depreciating the soil resources in the basin. Only one-fourth of the cropland in the basin is adequately protected from erosion. This leaves three-fourths of the basin's cropland needing immediate application of conservation measures to protect it as a producer of food and fiber.

GULLY EROSION

Gullies void and dissect the land. They also increase the amount of eroded soil reaching streams and lakes (Worth County, Missouri).

Recommendations

1. All agencies develop better data on long-term and short-term effects of erosion to assist in convincing the landowner of the importance of erosion control.

2. All local, State, and Federal agencies interested in preserving the land resource base should increase efforts to inform the general public of the condition of our soil resource and the importance of preserving the soil resource for future food and fiber production.

3. The State develop a plan that would identify objectives, set priorities, coordinate input, and recommend policy to achieve needed conservation measures.

4. All agencies should promote and accelerate programs to acquire application of conservation measures.

C. Forestry

The forested lands of the basin are in poor condition. Almost 45 percent of the trees have no commercial value other than firewood. As a result forest resources receive relatively minor consideration and are being converted to other uses.

Improper grazing is a major problem that occurs on nearly 66 percent of the forest land. Such grazing increases erosion, reduces forest reproduction, changes stand composition and lowers timber quality. Erosion from grazed forest lands averages 4.95 tons per acre per year and totals 3.6 million tons within the basin.

Recommendations

1. Accelerate an information program to inform landowners of forest land management opportunities.

2. All agencies should promote livestock exclusion and proper forest management on forest lands with serious erosion problems.

D. Stream Systems And Streambank Erosion

The development of the basin by the white man severely altered the stream systems. Major factors contributing to changes are (1) conversion of approximately one-third of the basin's permanent vegetative cover to annually tilled cropland which has increased runoff and sediment delivered to streams, and (2) straightening stream channels which has increased velocities that have caused channels to degrade and banks to erode. Erosion resulting from land conversion and channel straightening contribute to sediment overloads resulting in instream sediment deposition. This study indicates that most of the degrading (cutting) cycle from the straightening of stream channels has been completed, and the aggrading (filling) cycle of mainstream channels is now occurring. This is especially true on the Grand and Chariton River systems. Exceptions occur in specific locations, especially on upper extremities of tributaries. During the degrading cycle, the streams tend to remain straight and have increased capacity for flood control; when aggrading occurs, streams lose their capacity for flood control. Aggradation is the predominant stream characteristic of the basin's streams. However, stream dynamics are never simplistic. For any given stream reach aggrading, degrading or equillibria conditions may prevail. For example, the bottom of the Grand River at Sumner in the last 40 years has risen approximately 6 feet (629.5 to 635.5 elev.). During the same period the bottom of the Grand River at Gallatin has lowered 2 feet. Interviews with farmers have verified that the aggrading condition is moving upstream. This would indicate that much of the stream straightening in the 1920's provided increased flood protection for 40 to 50 years, but downstream aggradation is rapidly reducing flood protection. Stream straightening, unless done as a designed stable system, is only a temporary relief from flooding and often contributes to greater problems in the long run.

The 1920's was the channel straightening period. Approximately one-half of the major streams have been straightened. The 1970's and 1980's is the private levee construction period. This hodgepodge approach to construction of levees involves a lot of investment that will create future problems unless guided by a sound plan.

AN EFFECT OF IMPROPER CHANNELIZATION

Straightened streams in the basin are still readjusting. Soil lost from eroding streambanks immediately affects streams (Grundy County, Missouri).

Recommendations

1. Stream straightening on a large scale should not be promoted since it is not a practical long-term solution to providing flood protection. The Missouri Clean Water Commission's Channel Modification Guidelines should be followed.

2. Measures that have the best potential for improving the stablization of stream systems are:

    a. The State should delineate a floodway on all significant streams and have the authority to require construction of all levees according to plan. In rural areas, the planned floodway should be less than a 100-year floodway designated by FIA to minimize the impact on prime farmland. For instance, agriculture levees might be allowed up to 50-year frequency with no free board within FIA's floodway.

b. Maintain and reestablish riparian vegetation 100 feet wide along major streams.

c. Reduce sediment delivered to streams by stabilizing active gullies and applying conservation measures to seriously eroding cropland.

d. Reduce peak flows by applying conservation measures and other upstream structures to withhold more runoff.

E. Water Quality

Water quality in the basin was generally considered fair except during storm runoff. Conditions were uniform and similar in all subbasins except for localized problems. The basin relies heavily on surface and ground water for consumptive use.

Surface Water

The water quality of the basin will become increasingly important as more users compete for it as a resource base for domestic supply, for irrigation, and for recreation.

The quality of waters in ponds and lakes is generally better than the quality in streams, due at least in part to the variability of stream flow and greater drainage area of the stream systems. Common stream water quality problems are related to land use, low infiltration, and runoff. High flows are characterized by high levels of nutrients, pesticides, and suspended sediment. Low dissolved oxygen levels are common with low flows as well as increased concentrations of pollutants where point sources are not diluted. Serious localized quality problems are associated with coal mined lands and municipal treatment plant discharges.

Ground Water

Ground water from bedrock aquifers in the basin is not suitable for most uses because of dissolved minerals. Other aquifer sources are buried valleys, glacial drift, and alluvium associated with the major rivers. Waters from these sources are moderately hard to hard, and contain high levels of dissolved iron and total dissolved solids. The recommended drinking water standard for sulfate is violated at a few public locations. The maximum contaiminant level for nitrate is exceeded at one public location in the Missouri portion of the basin.

Recommendations

1. Promote application of conservation measures on cropland to reduce sediment and associated nutrients and pesticides.

2. Accelerate information program on proper application of nutrients and pesticides. The storage and disposal of empty containers also needs emphasis.

3. Promote better pasture management to reduce sediment, nutrients, and fecal coliform.

F. Water Supply

Over 140 public water systems provide drinking water in the Missouri portion of the basin. Water for these systems is furnished by 121 suppliers. Many of the systems serve small towns. For example, Nodaway County has 12 different source systems, but Buchanan County has only two systems. The primary source for these are wells (84), lakes (31), and streams (6). Most of the wells serve small towns and over one-half of these systems have problems with quantity and/or quality. Wells are generally the cheapest source of water, if available. However, this source is usually a problem in the eastern two-thirds of the basin except along major streams. Fifteen lake systems are expected to have inadequate storage by 2000. Missouri is blessed with a large number of potential reservoir sites with an average annual runoff of 5 inches in the west to 9 inches in the southeast corner of the basin. Therefore, developing a new water supply is not a physical problem in this basin. Storage in several of the existing reservoirs is being rapidly reduced by sedimentation. Considering all water sources, at least 50 new reservoir systems are projected to be needed by 2000.

Recommendations

1. A potential exists for combining small towns and rural water districts for more efficient systems. Regional master plans can guide this effort, but there remains a political problem between the involved entities. However, the State and other planners should continue to promote the need for developing water supply and treatment plants that serve a large portion or all of the county.

2. If wells are not adequate to meet future needs, reservoirs should be constructed as needed to serve a locale. Adequate sites are available and specific sites should be identified as the need arises.

3. When practical, the construction of a new water supply site should be combined with flood prevention reservoirs or other multi-purpose structures to obtain the most efficient expenditure of public funds.

4. Special priority should be placed on accomplishing the application of land treatment above existing municipal reservoirs to extend their life. Reservoirs identified with sediment or potential sediment problems are Maysville, Dearborne, Hamilton, Harrison PWSD # 1, Jamesport, Mercer, and Milan.

5. Programs should be developed to manage watersheds above municipal reservoirs to improve water quality.

G. Flooding

Flooding is a severe problem on most flood plains in the basin. The basin is blessed with large flat flood plains with good, productive agricultural soils. Over 70 percent of the bottom land is used as cropland. However, most of this cropland is flooded several times a year causing over $32 million average annual damage to 1 million acres of flood plain in rural areas.

Urban flood damages occur in 93 of the 210 towns in the basin and were not analyzed in this report. In most cases, the flooding is limited to a small section of the town.

Flooding was most severe in the Lower Grand River subbasin ($10,186,600 or $4,230/square mile of drainage area). The Upper Grand, Little Chariton, Lower Chariton, Lower Nodaway, 102 River, and Thompson River subbasin ranged from $1200 to $2500 of average annual damage per square mile of drainage area. The Tarkio, Upper Nodaway, Platte, and Upper Chariton had the least average annual damage per square mile of drainage area ranging from $600 to $1200. Individual drainage areas in each basin may significantly exceed or be below the basin average, depending on its physical characteristics.

Flood plains represent 23 percent of the basin and produce over 36 percent of the grain crops in the basin. This percentage is based on acres harvested and does not include yield differential which would increase the percentage. Maintaining the bottom land as productive cropland is very closely related to the erosion problem in the uplands. Any reduction of cropping in the bottom land would increase the pressure on the land user to convert marginal upland to cropland to meet the demands for crop production.

In the past, when the cost of raising a crop was considerably less, farmers were not as concerned about the flooding, as they could afford to take the risk and raise a fair crop most years. The high cost of production and the economic risks associated with farming in bottom land are causing many landowners to construct private levees because of the high risk associated with large investments and narrow margins of profit. Most of these levees are not part of a planned system and will compound any long-term solution to basin flooding. In most cases, a system of upstream reservoirs and downstream levees associated with a floodway appears to be the best solution to protecting bottom land for agricultral production.

Recommendations

1. A detailed plan to assist implementation of measures for reducing flooding in the Lower Grand River basin be developed in Phase II of this study.

2. The State of Missouri, based on local support, initiate new basin studies to develop detailed plans for reducing flooding in the Upper Grand, Little Chariton, Lower Chariton, Lower Nodaway, 102 River, and Thompson River basins.

3. The State of Missouri should assume an active role in promoting flood protection of agricultural bottom land to maintain production and reduce pressure on converting rolling upland to cropland.

4. The State assume a stronger role in developing policy and managing stream channels and floodways. For instance, agricutural levee systems that provide a 50-year protection when inside the 100-year floodway could be promoted, but should not infringe on a minimum floodway needed for a 25-year storm. (See item 3a in Stream Systems and Streambank Erosion.)

FLOODED CROPLAND

Over 1 million acres of flood plain are damaged annually by frequent flooding. Most of this estimated 32 million dollars of damage occurs in the rural areas of the basin. Flooding seriously affects food production, since flood plains account for 36 percent of the basin's grain crop production (Clay County, Missouri).

H. Upland Wildlife

Wildlife habitat conditions in seven counties in 1939 were compared to 1974 conditions (see map 31). The study indicated that mixed changes occurred with an overall reduction in habitat. However, good habitat is still available in most of the basin. The major factors contributing to poorer conditions were (1) conversion of grasslands to fescue, (2) removal of woody cover and fence rows along roads and between fields to create larger fields, (3) herbicide reduction of field residue, and (4) reduced use of Korean lespedeza.

Recommendations

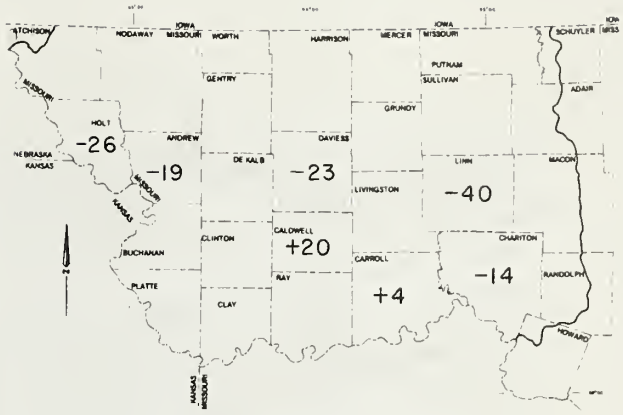
1. Promote planting some of the pastures to warm season grasses.

2. Encourage leaving crop residue in the field until spring.

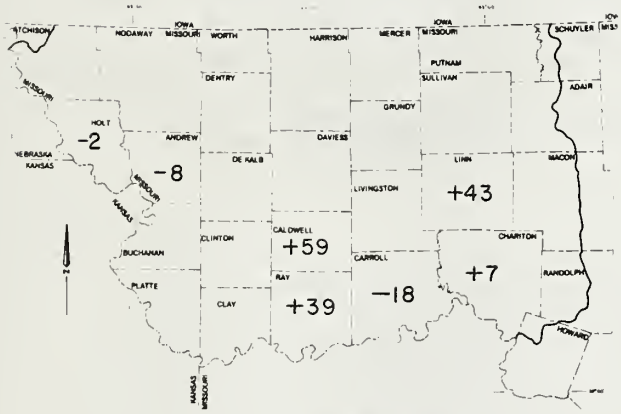
3. Promote vegetative turnrows and other permanent vegetation around fields and in fence rows.

4. Promote grass back terraces in deep loess areas along the Missouri River where much of the poorer habitat exists.

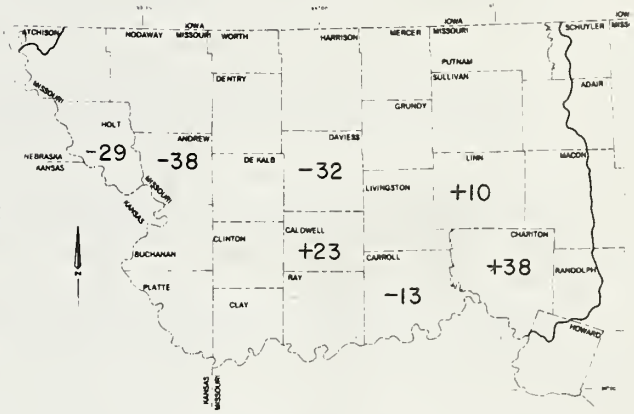
Habitat Diversity Index



Interspersion Index



Edge Index



Vegetative Index of Fields

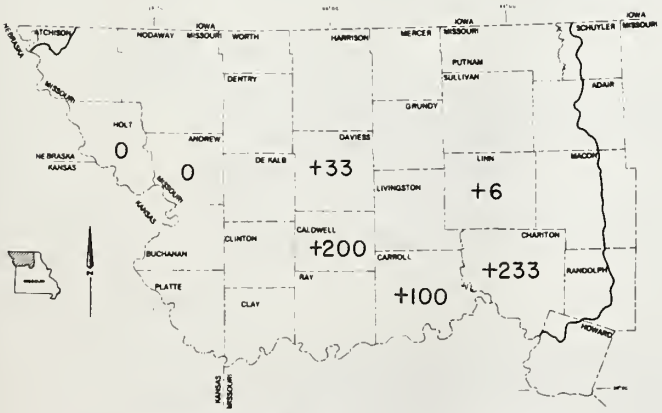
LEGEND

——— STATE BOUNDARY

——— COUNTY BOUNDARY

BASIN BOUNDARY

± % CHANGE 1939-1974



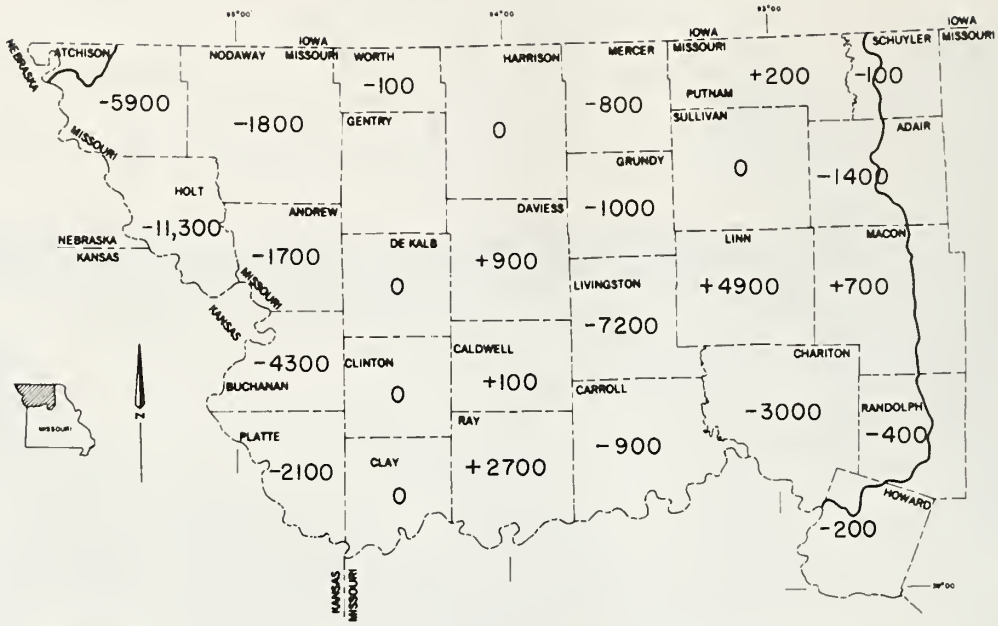
Vegetative Index of Woodlands

MAP 31

WILDLIFE HABITAT CHANGE 1939-1974

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

MISSOURI



LEGEND

——— STATE BOUNDARY
— — — COUNTY BOUNDARY
~~~~ BASIN BOUNDARY

MAP 32
WETLANDS CHANGES IN ACREAGE 1955-1977
MISSOURI
NORTHERN MISSOURI RIVER
TRIBUTARIES BASIN
MISSOURI AND IOWA
~~~~

I. Wetlands

The basin contains some of the more important wetlands in the state--Squaw Creek National Wildlife Refuge, Fountain Grove Wildlife Area, and Swan Lake National Refuge. A comparison of wetlands in the basin in 1955 (62,606 Acres) to 1977 (35,423 Acres) indicates over a 40 percent loss of wetlands in 22 years. The two main factors causing loss of wetlands are (1) sedimentation and (2) drainage by landowners. Land values, and consequently, land taxes have increased. Tax increases have encouraged the landowner to seek more economic return. The location of these changes are mixed, as some counties are showing gains and others show a loss (refer to map no. 32). Most of the counties along the Missouri River and Lower Grand River are showing a severe loss. Stopping the loss of wetland habitat is critical if the basin is to continue to be an important area for waterfowl and other species associated with wetlands.

Recommendations

1. An information program be accelerated to inform landowners of the importance of wetlands.

2. State of Missouri should identify and acquire the large remaining wetlands.

3. An incentive program for easement be initiated to maintain wetlands that are privately owned.

J. Recreation

Additional water based recreation is not a major problem in the basin. The Ozarks, with their plentiful high quality lake facilities, are within 100 miles of most of the basin's population. Therefore, demand for large overnight type facilities is limited. However, there is an additional need for small day-use lakes primarily for water skiing, fishing, and picnicking. One to two lakes per county would be desirable. The area of attraction for these lakes would primarily be a 20 mile radius. However, finding an agency to develop and maintain these types of lakes for skiing is a problem, as very few county courts are interested in recreation development. The Missouri Department of Conservation has placed priority on developing fishing lakes.

Recommendations

1. Any project activity involving the construction of dams should identify a recreation sponsor and select at least one site per county for public recreation sponsorship.

2. Acquire access to streams and develop public day use facilities.

K. Irrigation

The use of water for irrigation in the basin has been very minimal, less than 1 percent (21,400 Acres) of cropland was irrigated in 1977. This cropland is only supplementally irrigated with about 6 inches of water per year.

However, irrigation in the last 10 years has increased over 500 percent (from 4,000 acres to 21,400 acres). The high risk of reduced yields from short midsummer drought periods, associated with high investment cost and high interest, is forcing the landowner to look for protection. Therefore, the future expansion of irrigation is projected to continue with the present economic conditions.

A review of soils data indicated that 5,383,000 acres or 62 percent of the basin in Missouri could be irrigated. This is not expected to occur in the foreseeable future, as only approximately 100,000 acres are projected to be irrigated by the year 2000. Most of the basin has over 6 inches of average annual runoff so adequate water should be available for irrigation. However, potential conflicts with instream flows can develop if the State does not develop and implement policy on use of water for irrigation. Irrigation water comes from three sources: (1) wells, (2) impoundments, and (3) streams.

The ground water of the basin is not adequate to supply irrigation waters. Many of the wells in the eastern half of the basin are high in salts, including sodium, and the long-term effects on clay pan soils is not known.

Streams are a cheap source of water for irrigation, but usually have very low flows when irrigation is needed. For example, the Grand River at Sumner in August, 1980 only had 90 cfs. The irrigation of 7,000 more acres would have completely dried up the river. Therefore, significant irrigation from streams does not appear feasible due to the conflict with maintaining stream flow during drought periods.

Many excellent sites for impoundments exist. The construction of reservoirs with irrigation storage is the best potential water source for increasing irrigation. Most potential dams would be located on ephemeral streams and would be filled from storm runoff. Irrigation of 100,000 acres would use less than 2.5 percent of the average annual yield of water in the basin.

Increasing demands for irrigation water will produce conflicts. Present laws create situations where landowners risk the loss of large investments. For example, under present law a landowner can construct a dam relying on the present drainage for adequate yield to provide return on his investment. Later, a landowner immediately upstream could construct a dam and intercept his water supply making his investment worthless.

Recommendations

1. The State should have the authority to regulate the use of water for irrigation.

2. Additional research should be conducted on long-term effects of using high salt well water on clay pan soils.

3. Accelerate the preparation of irrigation guides and economic analyses to assist landowners in making sound decisions.

L. Missouri River Flood Plain Drainage Systems

The Missouri River flood plain is intensively cropped and contributes a large share of food and fiber production in Missouri. A study of adequacy of drainage outlets into the Missouri River was made to determine the effects of different levels of released flows in the Missouri River. The low flow studied (43,500 cfs. at Kansas City) indicated a minor impact on agricultural production affecting less than 2 percent of the 365,840 acre flood plain. However, the high flow (67,300 cfs. at Kansas City) showed a major impact on the important agricultural flood plain affecting the outlets for 11 percent of the area. The difference in two levels of the river significantly affects 33,000 acres.

Recommendations

1. Corp of Engineers operate upstream reservoir system to maintain flow at Kansas City at more than 43,500 cfs. during the cropping season. Extra water should be released before or after the growing season.

2. Implementation studies for pumping plant drainage systems should be started where present systems are inadequate. These areas are primarily in Holt, Platte, and Ray Counties.

M. Inventory Report Conclusion

This report presented data related to land and water for the entire resource basin. Basin reports normally present alternative solutions and a recommended plan. However, due to the size of the study area and the complexity of the problems, funds and staff are not available to undertake a basin wide solution analysis. Therefore, a decision was made to limit the second phase to studying solutions of erosion and flooding problems in the Lower Grand River subbasin. This decision was made based on highest priority needs identified in this report. The study of alternative solutions in the Lower Grand River subbasin will facilitate implementation of projects in this basin and will serve as an example for similar problems in the remainder of the basin. The results of the Lower Grand River study will be provided in a separate report.

In summary, both upland and bottom land soils in this basin play an important role in food and fiber production for the Nation. The upland soils are rapidly deteriorating because of erosion. Bottom land soils are becoming economically marginal due to high production costs and increasing losses caused by flooding. Maintaining agricultural production without depleting our soil resources needs the immediate attention and joint effort of local, State, and Federal agencies to provide food and fiber for future generations.

This floodwater retarding structure in a completed watershed project is one appproach to protecting the soil resource, reducing flooding, increasing landscape diversity, and increasing recreational opportunities (Nodaway County, Missouri).

APPENDIX A

Floodwater problem summaries in the eight subbasins:

Tarkio River and Direct Tributaries to Missouri River
Nodaway River
Platte River
Upper Grand River
Thompson River
Lower Grand River
Chariton River
Direct Tributaries

Appendix A

Summaries of floodwater problems in each of the eight subbasins of the Northern Missouri River Tributaries Basin are given here.

Tarkio River and Direct Tributaries to Missouri River
(Hydrologic Units 10240005 and 10240011)

This subbasin grouping includes two unconnected hydrologic unit areas with a total drainage area of 1,767 square miles (Map 20).

Hydrologic Unit Code	Drainage Areas		
	Iowa	Missouri	Total
	square miles		
10240005	327	1,041	1,368
10240011	None	399	399
Total	327	1,440	1,767

Hydrologic Unit Area 10240011 borders the east bank of the Missouri River between the outlets of the Nodaway and Platte Rivers. This unit has very large capacity channels, rare flooding and no significant floodwater problems.

Hydrologic Unit Area 10240005, with the Tarkio River as the major stream, has an estimated average annual floodwater damage of $840,300. The streams in this grouping have a combined flood plain acreage of 40,370 acres. Outlets of these Missouri River tributaries are leveed across the Missouri River bottoms. Floodwater problems below the levees are caused by the Missouri River. No floodwater damages were evaluated for the Missouri River bottom alluvium.

Present floodwater damages identified in the Tarkio River Subbasin Hydrologic Unit Area 10240005 total $840,300 (Table 48). Crop and pasture damages make up 81.6 percent of the identified floodwater damages.

Table 48 -- Average Annual Floodwater Damages, Tarkio River Subbasin, Northern Missouri River Tributaries Basin, Iowa and Missouri

Item	Av. An. Floodwater Damages	
	Dollars	Percent
Crop and Pasture	685,130	81.6
Other Agricultural	38,750	4.6
Sediment	2,570	0.3
Scour	580	
Road and Bridge	36,860	4.4
Other	76,410	9.1
Total Damage	840,300	100.0

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MAP 20

REACH — FREQUENCY

TARKIO RIVER AND DIRECT TRIBUTARIES SUBBASIN

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

IOWA AND MISSOURI

SOURCE:
SCS DRAWING NO. 5-5-34-549-1 AND INFORMATION FROM SCS FIELD PERSONNEL
POLYCONIC PROJECTION

8-28-80
5,R.37,632

Table 50 summarizes the floodwater damages by watersheds and types of damages. Flood plain land damages are minor. There were 500 acres of sediment damage and 50 acres of scour damage identified. There are also 107 acres of agronomic damages from untimely sediment deposition affecting plants.

Both hydrologic units are in Land Resource Area 107, Iowa and Missouri, deep loess hills. Flood plain land use consists of 81 percent cropland, 10 percent pastureland, 5 percent forest land, and 4 percent other land.

Reach-Frequency Map 20 was prepared to illustrate the variation in floodwater damages. In general, the more frequently a reach floods the greater the damages. The frequency of flooding has been related to the percent of flood plain flooded and damages per acre in Table 49.

Table 49 -- Percent Flood Plain and Damage per Acre by Frequency of Recurrence, Hydrologic Unit Code 10240005, Northern Missouri River Tributaries Basin, Iowa and Missouri

States	Frequency* (Av. Yrs.)	Flood Plain (Av. %)	Damages per Acre	
			Crop & Pasture	Total
			----Av. $ per acre----	
Iowa	0.0-1	57	51	61
	1.1-2	--	--	--
	2.1-5	--	--	--
	5.1 or greater	43	4	9
Missouri	0.0-1	41	26	31
	1.1-2	22	15	18
	2.1-5	8	4	6
	5.1 or greater	29	2	2

* 0.0 to 1.0 - Floods more than once per year.
1.1 to 2.0 - Floods on the average between 1.1 to 2.0 years
2.1 to 5.0 - Floods on the average between 2.1 to 5.0 years
5.1 or greater - Floods on the average 5.1 years or greater

Nodaway River Subbasin (Hydrologic Units 10240009 and 10240010)

The Nodaway River Subbasin is divided into two hydrologic unit areas as designated by the U.S. Water Resources Council (Map 19, page 96). The subbasin drainage area is 1,820 square miles; 1,230 square miles in Iowa and 590 square miles in Missouri.

Table 50 -- Average Annual Floodwater Damage, Hydrologic Unit Code 10240005, Tarkio River and Smaller Direct Tributaries to Missouri River, Northern Missouri River Tributaries Basin, Iowa and Missouri

No.	Watershed Name	Drainage Area Sq. Mi.	Evaluated Flood Plain Acres	Crop and Pasture	Average Annual Floodwater Damages						
					Other Agr.	Agronomic Sediment Damages	Land Damages Sediment	Land Damages Scour	Road and Bridge	Other****	Total
					dollars						
1	Tarkio River, Ia.*	207.7									
1	Tarkio River, Mo.**	62.4	6850	172410	8620				2520	18360	201910
2	West Tarkio Cr., Ia.**	110.4	6200	189900	14000				14000	21800	239700
2	West Tarkio Cr., Mo.**	56.6	4880	74660	3730				2500	8090	88980
3	Rock Creek, Mo.**	154.9	1960	4840	240				1180	630	6890
4	Lower Tarkio R., Mo.**	80.0	7190	129660	6480				3300	13940	153380
5	Little Tarkio Cr., Mo.	190.0	8260	104440	5220	930	1640	580	9990	12280	135080
6	Squaw Cr., Mo.**	184.0	4290	8980	450				2900	1240	13570
7	Mill-Easter Cr., Mo.**	63.0	740	240	10				470	70	790
	Missouri River Bottom Land***	259.0									
	Totals	1368.0	40370	685130	38750	930	1640	580	36860	76410	840300

Price base: current normalized for agriculture (Oct. 1976, WRC) 1970-1974 crop yields

* Insignificant damage
** No significant land damage
*** No floodwater damage analyzed in study
**** Certain losses resulting from flooding even though the property involved was not flooded.

Hydrologic Unit Code	Drainage Areas		
	Iowa	Missouri	Total
	square miles		
10240009	813	none	813
10240010	417	590	1,007
Total	1,230	590	1,820

Crop and pasture damages account for about 77 percent of the $697,300 average annual damages in hydrologic unit 10240009 (Table 51). In hydrologic unit 10240010, crop and pasture damages account for 78 percent of $1,295,800 average annual damages.

Table 51 -- Average Annual Floodwater Damages by Hydrologic Units, Nodaway River, Northern Missouri River Tributaries Basin, Iowa and Missouri

Item	10240009		10240010	
	$1,000	Percent	$1,000	Percent
Crop and Pasture	535.9	76.9	1,015.3	78.4
Other Agricultural	49.0	7.0	70.6	5.4
Agronomic Sediment	--	--	5.0	0.4
Land Sediment	--	--	35.0	2.7
Land Scour	--	--	1.5	0.1
Roads and Bridges	49.0	7.0	50.6	3.9
Other	63.4	9.1	117.8	9.1
Total Damage	697.3	100.0	1,295.8	100.0
Flood Plain Acres	45,529		60,734	

Hydrologic Unit 10240009 contains 15 watersheds, all in Iowa (Map 19, page 96). West Douglas Watershed No. 3 is a completed PL-566 watershed. Watershed numbers 5, 9, 10, 11, 12, 13, and 14 have large channels, and flood damages are not significant.

The nine watersheds in Hydrologic Unit 10240010 are located in Iowa and Missouri. Walters Creek Watershed Number 16, in Iowa, is a PL-566 watershed under construction. Hoover-Frankum Watershed No. 22 is a completed PL-566 watershed. Buchanan Watershed No. 18 has no significant floodwater damages.

Flood damages were calculated for 13 watersheds, 9 watersheds in Iowa and 4 watersheds in Missouri. Present floodwater damages estimated for the subbasin amount to $1.99 million annually on 106,260 acres of flood plain lands (Table 52). No significant flood plain land damages were identified in the Iowa area of this subbasin.

Most of the Nodaway River in Missouri has been channeled and leveed. Sand deposition is occurring in the upper channel reaches. Significant flood

Table 52 -- Average Annual Floodwater Damage, Hydrologic Unit Codes 10240009 and 10240010, Nodaway River Subbasin, Northern Missouri River Tributaries Basin, Iowa and Missouri

No.	Watershed Name	Drainage Area Sq. Mi.	Evaluated Flood Plain Acres	Average Annual Floodwater Damages							
				Crop and Pasture	Other Agr.	Agronomic Sediment Damages	Land Damages Sediment	Land Damages Scour	Road and Bridge	Other***	Total Damage
				dollars							
				HYDROLOGIC UNIT CODE 10240009							
	Other Watersheds*	101									
1	Middle Nodaway, Ia.	89	5060	204620	11390				11390	22740	250140
2	W.F. Middle Nodaway, Ia.	129	4300	75560	9680				9680	9500	104420
4	Middle Nodaway, Ia.	113	9240	43290	7780				7780	5880	64730
6	West Nodaway, Ia.	124	4054	30950	7030				7030	4500	49510
7	Seven Mile, Ia.	124	6830	168790	11930				11930	19260	211910
8	West Nodaway, Ia.	61	1225	360	11930					40	400
19	Nodaway, Ia.	72	14820	12280					1220	1470	16190
	Total	813	45529	535850	49030				49030	63390	697300
				HYDROLOGIC UNIT CODE 10240010							
	Other Watersheds**	121									
15	E.F. of E. Nodaway, Ia.	22	350	13720	790				790	1530	16830
17	East Nodaway, Ia.	262	20305	229900	31280				31280	29250	321710
20	Mill Creek, Mo.	84	3021	15240	760	100	2130	660	340	1920	21150
21	Clear, Cayhouga, Muddy, Mo.	116	8599	102430	5120	670	2600	810	4200	11580	127410
23	Upper Nodaway Trib's, Mo.	207	14761	347440	17370	2260	4340		7170	37860	416440
24	Lower Nodaway Trib's, Mo.	195	13698	306580	15330	2000	25960		6780	35660	392310
	Total	1007	60734	1015310	70650	5030	35030	1470	50560	117800	1295850
	Grand Total	1820	106263	1551160	119680	5030	35030	1470	99590	181190	1993150

Price base: current normalized for agriculture (Oct. 1976, WRC) 1970-74 crop yields

* Watershed Nos. 3, 5, 9, 10, 11, 12, 13, and 14
** Watershed Nos. 16, 18, and 22
*** Certain losses resulting from flooding even though the property involved was not flooded.

plain sediment deposition is occurring along stream reaches subject to flooding. Along the mainstem of the Nodaway River 2,400 acres of damaging sediment deposits and 100 acres of scour damage were identified.

The average annual agronomic sediment damages evaluated for 508 acres are caused by: (1) additional tillage operation and applications of fertilizer, pesticides, and insecticides on an evaluated 109 acres, (2) wetness problem resulting in delayed seeding and reduced yields of 10 percent on corn and beans on an evaluated 127 acres, and (3) sediment deposition to young plants requiring replanting on an evaluated 272 acres of corn and beans.

Nodaway River Subbasin is situated in Land Resource Area 107, the Iowa and Missouri deep loess hills, and Land Resource Area 108, the Illinois and Iowa deep loess drift. Land use in the flood plain consists of 87 percent cropland, 4 percent pastureland, 7 percent forest land, and 2 percent other lands.

A reach-frequency map (Map 21) was prepared to illustrate the variation in floodwater damages. In general, the more frequently a reach floods the greater the damages. The frequency of flooding has been related to the percent of flood plain flooded and damages per acre in Table 53.

Table 53 -- Percent Flood Plain and Damage Per Acre by Frequency of Recurrence, Hydrologic Unit Codes 10240009 and 10240010, Northern Missouri River Tributaries Basin, Iowa and Missouri

Hydrologic Units	Frequency* (Av. Yrs.)	Flood Plain (Av. %)	Damages per Acre	
			Crop & Pasture	Total
			-----Av. $ per Acre---	
10240009	0.0-1	24	36	44
	1.1-2	6	20	27
	2.1-5	13	10	16
	5.1 or greater	57	1	1
10240010	0.0-1	37	31	38
	1.1-2	18	17	20
	2.1-5	24	7	11
	5.1 or greater	21	2	4

* 0.0 to 1.0 - Floods more than once per year
1.1 to 2.0 - Floods on the average between 1.1 to 2.0 years
2.1 to 5.0 - Floods on the average between 2.1 to 5.0 years
5.1 or greater - Floods on the average 5.1 years or greater

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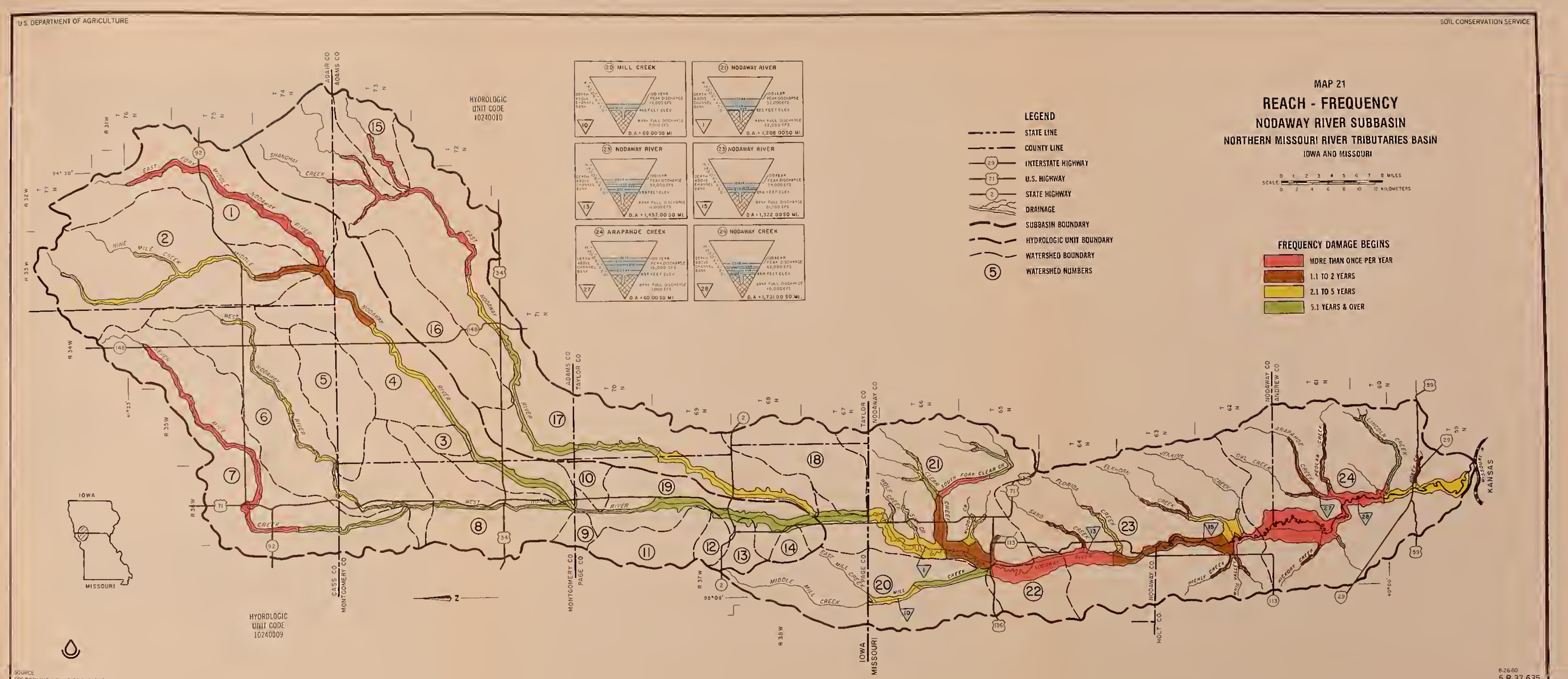

Platte River Subbasin (Hydrologic Units 10240012 and 10240013)

Platte-102 River Subbasin is part of the Northern Missouri River Tributaries Basin in Iowa and Missouri and is designated by the U.S. Water Resources Council as Platte River Hydrologic Unit 10240012 and 102 River Hydrologic Unit 10240013 (Map 22). The subbasin has a total drainage area of 2,419 square miles, 786 square miles in Iowa and 1,633 square miles in Missouri.

Hydrologic Unit Code	Drainage Areas		
	Iowa	Missouri	Total
	square miles		
10240012	398	1,280	1,678
10240013	388	353	741
Total	786	1,633	2,419

Present floodwater damages identified in the subbasin are $2,068,300; $1,024,800 in Hydrologic Unit 10240012 and $1,043,500 in Hydrologic Unit 10240013 (Table 54).

Table 54 -- Average Annual Floodwater Damages by Hydrologic Units, Platte River Subbasin, Northern Missouri River Tributaries Basin, Iowa and Missouri

Item	Platte River 10240012		102 River 10240013	
	$1,000	Percent	$1,000	Percent
Crop and Pasture	732.3	71.5	760.8	72.9
Other Agricultural	45.9	4.5	42.1	4.0
Agronomic Sediment	16.5	1.6	13.0	1.2
Land Damages	48.4	4.7	72.7	7.0
Road and Bridges	88.6	8.6	60.1	5.8
Other	93.1	9.1	94.8	9.1
Total Damage	1,024.8	100.0	1,043.5	100.0
Flood Plain Acres	72,616		44,684	

Present flood damages were calculated for 12 watersheds in the Platte River Subbasin and 8 watersheds in the 102 River Subbasin (Table 55). No significant flood plain land damages were identified in the Iowa area of the subbasin.

In the Platte River Hydrologic Unit Code 10240012, the Platte River Tributaries Watershed No. 5 is a PL-566 completed watershed. In the 102 River Hydrologic Unit Code 10240013, the 102 River Tributaries Watershed No.

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MAP 22
REACH — FREQUENCY
PLATTE RIVER SUBBASIN
NORTHERN MISSOURI RIVER TRIBUTARIES BASIN
IOWA AND MISSOURI

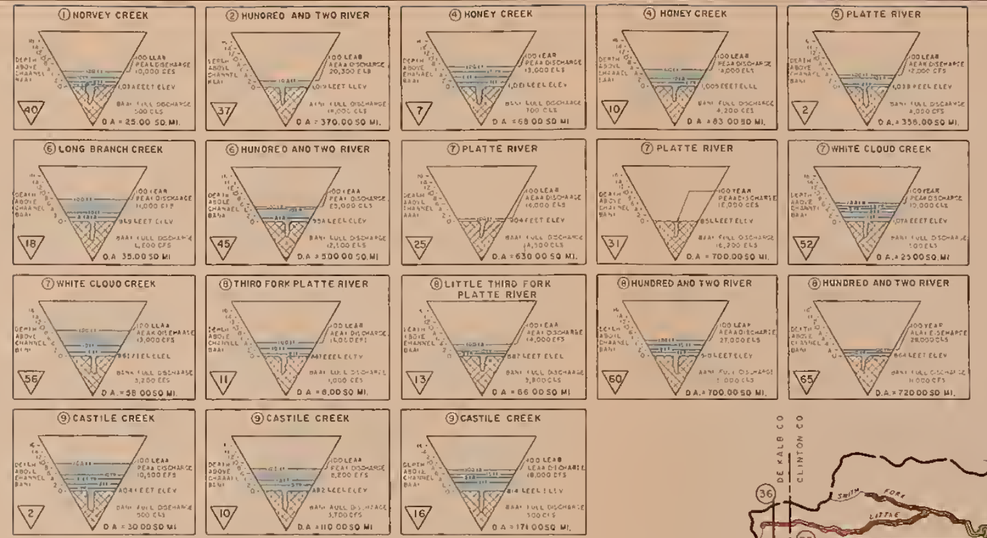
SCALE 0 1 2 3 4 5 6 7 8 MILES
0 2 4 6 8 10 12 KILOMETERS

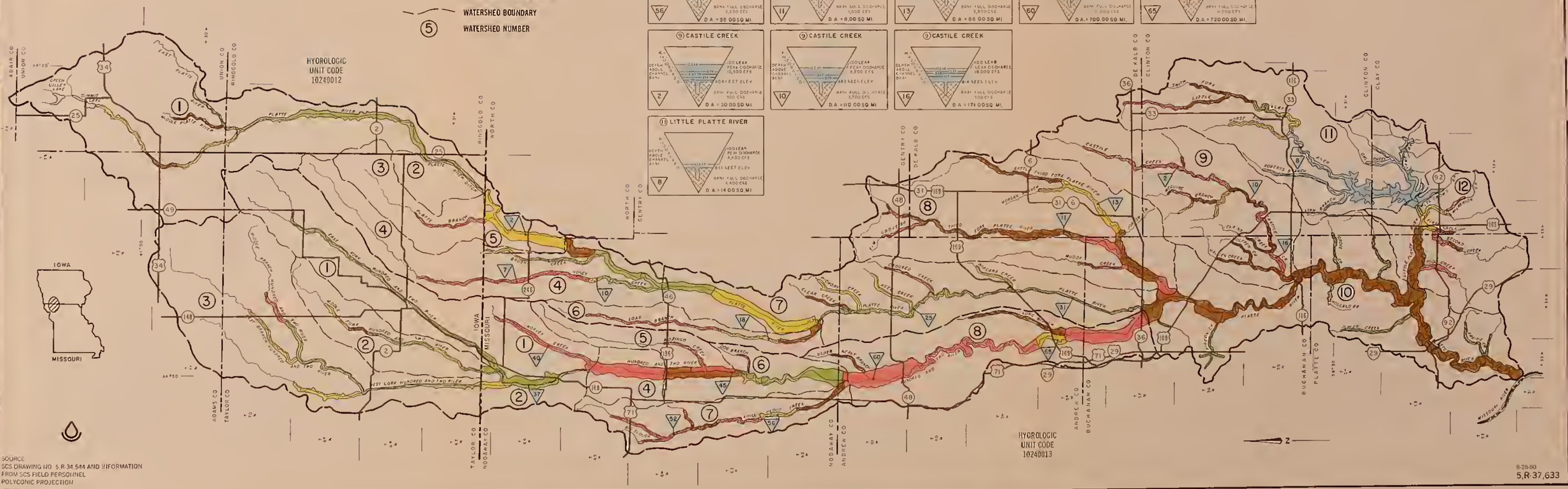
FREQUENCY DAMAGE BEGINS

- MORE THAN ONCE PER YEAR
- 1.1 TO 2 YEARS
- 2.1 TO 5 YEARS
- 5.1 YEARS & OVER
- RESERVOIR

LEGEND

- STATE LINE
- COUNTY LINE
- INTERSTATE HIGHWAY
- U.S. HIGHWAY
- STATE HIGHWAY
- LAKE
- DRAINAGE
- SUBBASIN BOUNDARY
- HYDROLOGIC UNIT BOUNDARY
- WATERSHED BOUNDARY
- WATERSHED NUMBER





SOURCE
SCS DRAWING NO. 5-R-34,544 AND INFORMATION FROM SCS FIELD PERSONNEL
POLYCONIC PROJECTION
USDA SCS-LINCOLN, NEB. 1980

8-29-80
5,R-37,633

Table 55 -- Average Annual Floodwater Damage, Platte River Subbasin, Hydrologic Unit Codes 10240012 and 10240013, Northern Missouri River Tributaries Basin, Iowa and Missouri

No.	Watershed Name	Drainage Area Sq. Mi.	Evaluated Flood Plain Acres	Crop and Pasture	Other Agr.	Agronomic Sediment Damage	Land Damages	Roads and Bridges	Sub-Total	Other***	Total Damage
				dollars							
	PLATTE RIVER HYDROLOGIC UNIT CODE 10240012										
1	Platte River, Ia.	258	7003	23220	7020			7020	37260	3720	40980
2	Blockton Watershed, Ia.	29									
3	Platte Branch, Ia.	51	250	17910	3400			3400	24710	2470	27180
4	Honey Creek, Ia. & Mo.	131	7336	84580	5140	1640	15750	880	115910	11590	127500
5	Platte River Tribs, Mo.*	20	4417	18020	900	440	1670	260	21290	2130	23420
6	Long Branch, Mo.	44	2127	10490	520	260	7420	8420	27110	2710	29820
7	Upper Platte River, Mo.	191	11978	58570	2930	1440	10100	6900	79940	7990	87930
8	Third F. Platte R., Mo.	233	13506	194980	9750	4790	5500	18750	233770	23380	257150
9	Castile Creek, Mo.	169	5613	84380	4220	2070	1100	20770	112540	11250	123790
10	Lower Platte River, Mo.	255	14217	172740	8640	4240	6630	4050	196300	19630	215930
11	Upper Little Platte R. Mo.	203	2287	7910	380	200	70	5110	13670	1370	15040
12	Lower Little Platte R. Mo.	94	3882	59490	2970	1460	120	5090	69130	6910	76040
	Totals	1678	72616	732290	45870	16540	48360	88570	931630	93150	1024780
	102 RIVER HYDROLOGIC UNIT CODE 10240013										
1	E. Fork 102 R. & Norvey Cr., Ia. and Mo.	141	5914	24660	1160	610	2450	6030	34910	3490	38400
2	Middle F. 102 R, Ia. & Mo.	108	2309	11180	1450		2400	1240	16270	1630	17900
3	W. Fork 102 River, Ia.	212	4895	32170	6980			6980	46130	4600	50730
4	102 River Tribs., Mo.*	20	3637	127150	6360	3120	9080	2160	147870	14780	162650
5	Mozingo Creek, Mo.**	38	5503	187050	7290		46380	14900	255620	25560	281180
6	Upper 102 River, Mo.	33	4310	39100	1960	960	10960	1800	54780	5480	60260
7	White Cloud, Mo.	44	3113	26600	1330	650	780	14280	43640	4360	48000
8	Lower 102 River, Mo.	135	15003	312850	15540	7680	690	12700	349460	34950	384410
	Totals	741	44684	760760	42070	13020	72740	60090	948680	94850	1043530
	Grand Totals	2419	117300	1493050	87940	29560	121100	148660	1880310	188000	2068310

* PL-566 watershed project completed
** PL-566 watershed authorized for planning
*** Certain losses resulting from flooding even though the property involved was not flooded.

Price base: current normalized for agriculture (Oct. 1976, WRC) 1970-74 crop yields

4 is a PL-566 completed watershed. Also Mozingo Creek Watershed No. 5 is a PL-566 watershed in planning.

The Corps of Engineers has constructed Smithville Reservoir, a 97,190-acre multipurpose pool, on the Little Platte River in Watersheds No. 11 and 12. The major project purposes are flood control, recreation, and municipal water supply. The project became operational for flood control in 1978. The dam controls a drainage area of approximately 210 square miles.

Sediment deposition has been identified on 11,456 acres. The damages vary from 2 to 22 percent and are estimated to be from 80 to 100 percent recoverable in one to two years with flood protection. Scour damages have been identified on 1,307 acres. Damage varies from 10 to 20 percent and is estimated to be 100 percent recoverable in one to two years with flood protection. Swamping damages have been identified on 40 acres. Damage varies from 5 to 10 percent and is estimated to be 100 percent recoverable in one year with flood protection.

Average annual agronomic sediment damages evaluated for 3,503 acres are caused by: (1) additional tillage operation and applications of fertilizer, pesticides and insecticides on an evaluated 753 acres, (2) wetness problems resulting in delayed seeding and reduced yields of 10 percent on corn and beans on an evaluated 876 acres, and (3) sediment deposition to young plants requiring replanting on an evaluated 1,874 acres of corn and beans.

The Platte-102 River Subbasin is situated in Land Resource Areas 107, 108, and 109. Land use in the flood plain consists of 73 percent cropland, 9 percent pasture, 13 percent forest land and 5 percent other land.

A reach-frequency map (Map 22) was prepared to illustrate the variation in floodwater damages. In general, the more frequently a reach floods the greater the damages. The frequency of flooding has been related to the percent of flood plain flooded and damages per acre in Table 56.

Table 56 — Percent Flood Plain and Damage per Acre by Frequency of Recurrence, Hydrologic Units 10240012 and 10240013, Northern Missouri River Tributaries Basin, Iowa and Missouri

Hydrologic Units	Frequency* (Av. Yrs.)	Flood Plain (Av. %)	Damages Per Acre	
			Crop & Pasture	Total
			------Av. $ per Acre-----	
10240012	1.0-1	19	22	30
	1.1-2	37	12	16
	2.1-5	25	4	7
	5.1 or greater	19	3	4
10240013	0.0-1	42	26	36
	1.1-2	6	7	11
	2.1-5	28	7	10
	5.1 or greater	24	2	6

* 0.0 to 1.0 - Floods more than once per year
1.1 to 2.0 - Floods on the average between 1.1 to 2.0 years.
2.1 to 5.0 - Floods on the average between 2.1 to 5.0 years.
5.1 or greater - Floods on the average 5.1 years or greater.

Upper Grand River Subbasin (Hydrologic Unit 10280101)

The Upper Grand River Subbasin has a drainage area 3,267 square miles, 507 square miles in Iowa and 2,760 square miles in Missouri. The present floodwater damages identified in this subbasin amount to $6.9 million annually (Table 57).

Table 57 — Average Annual Floodwater Damages, Upper Grand River Subbasin, Northern Missouri River Tributaries Basin, Iowa and Missouri

Item	Av. An. Floodwater Damages	
	1,000 dollars	Percent
Crop and pasture	5,436.8	79.1
Other agriculture	293.3	4.3
Agronomic sediment	2.1	---
Sediment	42.5	0.6
Swamping	1.2	---
Scour	84.8	1.2
Road and bridge	443.0	6.5
Other	571.9	8.3
Total Damage	6,875.6	100.0

Total evaluated flood plain is estimated to be 216,260 acres (Table 58). The Big Creek Watersheds, No. 8 and 9, are currently being planned as PL-566 watersheds. The Grindstone-Lost-Muddy Watershed work plan is currently being revised.

Table 58 -- Average Annual Floodwater Damage, Upper Grand River Subbasin, Hydrologic Unit 10280101, Northern Missouri River Tributaries Basin, Iowa and Missouri

No.	Watersheds Name	Evaluated Drainage Area Sq. Mi.	Evaluated Flood Plain Acres	Average Annual Floodwater Damages								
				Crop and Pasture	Other Agr.	Agron. Sediment Damages	Land Damage			Road and Bridge	Other**	Total Damage
							Sediment	Swamping	Scour			
				dollars								
1&2	W.F. Grand, Ia.	206	14470	160600	32550					32550	22570	248270
3	M.F. Grand, Ia.	-	2120	143250	4770					4770	15280	168070
3	M.F. Grand, Mo.	197	9990	132860	6640	140	10360		1040	11720	16280	179040
4	E.F. Grand, Ia.-Mo.	209	10340	103780	21040					20060	14490	159370
5	W.F. Grand, Mo.	308	22540	604820	30240				50480	29900	71540	786980
6	L.E.F. Grand, Mo.	218	13140	333260	16660	360	1140		2290	22740	37640	414090
7	Wh. Oak-Sampson, Mo.	224	17620	403490	20180	130	60	190	4740	35480	46430	510700
8	E.F. Big Cr., Ia.-Mo.	95	2610	75820	3790	80	5160			13820	9870	108540
9	W.F. Big Cr., Ia.-Mo.	294	14900	456890	19340	490	25460		970	58040	56120	617310
10	G-L-M Cr., Mo.*	327	16590	530090	13530					41840		585460
11	Upper Grand, Mo.	154	15800	407620	20380	390	160	530	13210	20400	46270	508960
12	Muddy Cr., Mo.	122	6800	128100	6400					23000	15750	173250
13	Marrowbone Cr., Mo.	102	2670	87980	4400					24530	11690	128600
14	Lower Grand, Mo.	198	33840	623460	31170	530	140	480	12090	15360	68320	751550
15	Upper Shoal Cr., Mo.	385	15090	500490	25020					46680	57220	629410
16	Lower Shoal Cr., Mo.	228	17740	744310	37220					42090	82360	905980
	Totals	3267	216260	5436820	293330	2120	42480	1200	84820	442980	571830	6875580

* Grindstone-Lost-Muddy PL-566 Watershed authorized for planning, projected 1980 yields, CN prices October 1977, WRC.

** Certain losses resulting from flooding even though the property involved was not flooded.

Price base: Current normalized for agriculture (October 1976, WRC) 1970-1974 Crop Yields

Sediment deposition has been identified on 3,995 acres. The damage, varying from 3 to 30 percent, is estimated to be from 90 to 100 percent recoverable in two years with flood protection. Scour damages have been identified on 6,890 acres. Damage is estimated at 10 percent and is 100 percent recoverable in one year with flood protection. Swamping damages have been identified on 200 acres. Damage is estimated at 5 percent and is 100 percent recoverable in two years with flood protection. Average annual agronomic sediment damages evaluated for 252 acres are caused by: (1) additional tillage operations and applications of fertilizer, pesticides and insecticides, (2) wetness problem resulting in delayed seeding, and (3) sediment deposition requiring replanting.

The Upper Grand River Subbasin is situated in Land Resource Area 109, Iowa and Missouri heavy till plain. Land use in the flood plain consists of 79 percent cropland, 7 percent pasture, 10 percent forest land, and 4 percent other.

A reach-frequency map (Map 23) was prepared to illustrate the variation in floodwater damages. In general, the more frequently a reach floods the greater the damages. The frequency of flooding has been related to the percent of flood plain flooded and damages per acre in Table 59.

Table 59 -- Percent Flood Plain and Damage per Acre by Frequency of Recurrence, Hydrologic Unit 10280101, Northern Missouri River Tributaries Basin, Iowa and Missouri

States	Frequency* (Av. Yrs.)	Flood Plain (Av. %)	Damages Per Acre	
			Crop & Pasture	Total
			-----Av. $ per Acre-----	
Iowa	0.0-1	35	29	37
	1.1-2	8	19	25
	2.1-5	21	6	11
	5.1 or greater	36	4	9
Missouri	0.0-1	56	38	48
	1.1-2	26	17	20
	2.1-5	5	10	12
	5.1 or greater	13	4	5

* 0.0 to 1.0 - Floods more than once per year.
1.1 to 2.0 - Floods on the average between 1.0 to 2.0 years.
2.1 to 5.0 - Floods on the average between 2.1 to 5.0 years.
5.1 or greater - Floods on the average 5.1 years or greater.

Thompson River Subbasin (Hydrologic Unit 10280102)

The Thompson River Subbasin has a drainage area of 2,205 square miles, 1,106 square miles in Iowa and 1,099 square miles in Missouri (Table 60).

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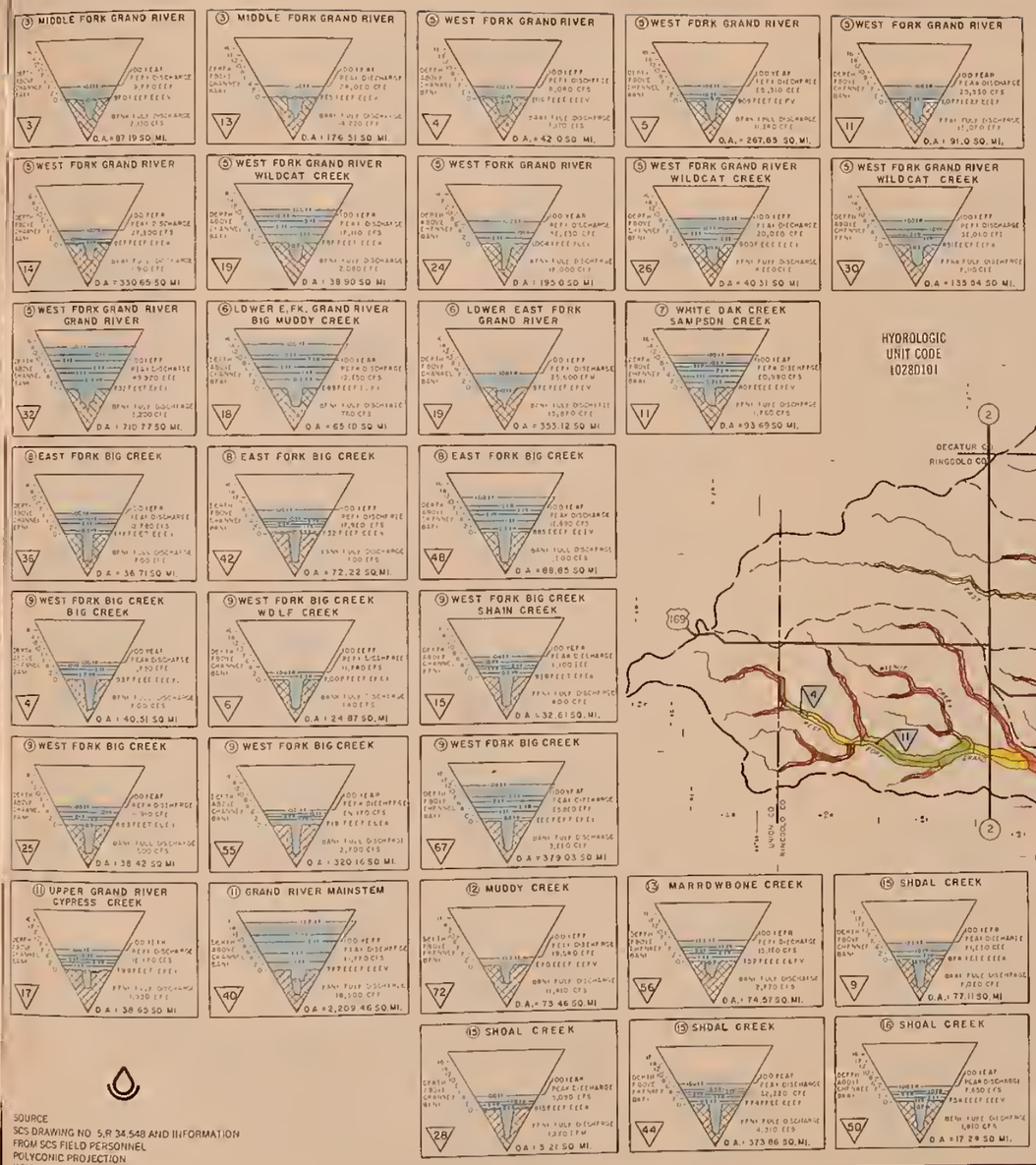

SOURCE
SCS DRAWING NO. 5,R 34,548 AND INFORMATION FROM SCS FIELD PERSONNEL
POLYCONIC PROJECTION

LEGEND

- STATE LINE
- COUNTY LINE
- (36) U.S. HIGHWAY
- (2) STATE HIGHWAY
- DRAINAGE
- SUBBASIN BOUNDARY
- WATERSHED BOUNDARY
- (8) WATERSHED NUMBER

FREQUENCY DAMAGE BEGINS

- MORE THAN ONCE PER YEAR
- 1.1 TO 2 YEARS
- 2.1 TO 5 YEARS
- 5.1 YEARS & OVER

HYDROLOGIC UNIT CODE 10280101

IOWA
MISSOURI

MAP 23

REACH - FREQUENCY

UPPER GRAND RIVER SUBBASIN

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

IOWA AND MISSOURI

SCALE 0 1 2 3 4 5 6 7 8 MILES
0 2 4 6 8 10 12 KILOMETERS

4-11-80
5,R-37,820

Table 60 -- Average Annual Floodwater Damage, Thompson River Subbasin, Hydrologic Unit 10280102, Northern Missouri River Tributaries Basin, Iowa and Missouri

No.	Watersheds Name	Drainage Area Sq. Mi.	Evaluated Flood Plain Acres	Average Annual Floodwater Damages								
				Crop and Pasture	Other Agri.	Agron. Sediment Damage	Land Damage			Road and Bridge	Other*	Total
							Sediment	Swamping	Scour			
				dollars								
1	Three Mile Cr., Ia.	57		(PL-566)								
2	Thompson R., Ia.	223	7440	407280	16750					16750	44080	484860
3	Twelve Mile Cr., Ia.	77		(PL-566)								
4	Sand Cr., Ia.	32		(NO FLOOD PLAIN)								
5	Long Cr., Ia.	124	4670	59210	10510					8780	7860	86360
6	Elk Cr., Ia.	66		(NO FLOOD PLAIN)								
7		22		(INCLUDED WITH WSHD. NO. 8)								
8	Thompson R., Ia.	129	17660	335160	39730					39730	41460	456080
9	U. Thompson R., Mo.	399	23750	315650	15780	2630	9380	1200	6840	31680	38320	421480
10	Panther Cr., Mo.	34		(PL-566)								
11	Little R., Ia.											
11	Little R., Mo.	140	2840	34110	1710	280	540	20	260	7960	4490	49370
12	Weldon R., Ia.	226	7860	266950	17680					17680	30230	332540
13	Weldon R., Ia.		2660	82430	5980					5980	9440	103830
13	Weldon R., Mo.	39	2260	59590	2980	490	130	20	90	2380	6570	72250
14	Muddy Cr., Ia.			(NO FLOOD PLAIN)								
14	Muddy Cr., Mo.	125	8390	71100	3560	590	70			12880	8820	97020
15	L. Thompson R., Mo.	295	43980	487140	24360	4050	16200	21220	77940	21560	65250	717720
16	Honey Cr., Mo.	217	16290	515890	25790	4300	490			43850	59030	649350
	Totals	2205	137800	2634510	164830	12340	26810	22460	85130	209230	315550	3470860

* Certain losses resulting from flooding even though the property involved was not flooded.

Price base: Current normalized for agriculture (October 1976, WRC) 1970-1974 yields

The present floodwater damages identified in the subbasin amounts to $3.5 million annually (Table 61). The evaluated flood plain is estimated at 137,800 acres.

Table 61 -- Average Annual Floodwater Damages, Thompson River Subbasin, Northern Missouri River Tributaries Basin, Iowa and Missouri

Item	Av. An. Floodwater Damages	
	1,000 dollars	Percent
Crop and pasture	2,634.5	75.9
Other agricultural	164.8	4.7
Agronomic sediment	12.3	0.4
Sediment	26.8	0.8
Swamping	22.5	0.6
Scour	85.1	2.5
Road and bridge	209.2	6.0
Other	315.6	9.1
Total Damages	3,470.8	100.0

No significant flood plain land damages are identified in the Iowa portion of the subbasin. In Missouri, damaging sediment deposits have been identified on 5,167 acres. The damage varies from 3 to 20 percent and is estimated to be from 50 to 100 percent recoverable in about two to three years with protection. Scour damages have been identified on 3,400 acres. The damage varies from 10 to 30 percent and is estimated to be from 90 to 100 percent recoverable in one to two years with protection. Swamping damages have been identified on 2,020 acres. This damage is 100 percent recoverable in one year with protection.

Average annual agronomic sediment damages evaluated for 1,308 acres are caused by: (1) additional tillage operations and applications of fertilizer, pesticides and insecticides, (2) wetness problems resulting in delayed seeding, and (3) sediment deposition requiring replanting.

The Thompson River Subbasin is situated in Land Resource Area 109, Iowa and Missouri heavy till plain. Land use in the flood plain consists of 76 percent cropland, 8 percent pasture, 12 percent forest land, and 4 percent other.

A reach-frequency map (Map 24) was prepared to illustrate the variation in floodwater damages. In general, the more frequently a reach floods the greater the damages. The frequency of flooding has been related to the percent of flood plain flooded and damages per acre in Table 62.

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HYDROLOGIC UNIT CODE 10280102

LEGEND

- STATE LINE
- COUNTY LINE
- INTERSTATE HIGHWAY
- U.S. HIGHWAY
- STATE HIGHWAY
- DRAINAGE
- SUBBASIN BOUNDARY
- WATERSHED BOUNDARY
- (2) WATERSHED NUMBER

FREQUENCY DAMAGE BEGINS

- MORE THAN ONCE PER YEAR
- 1.1 TO 2 YEARS
- 2.1 TO 5 YEARS
- 5.1 YEARS & OVER

MAP 24

REACH - FREQUENCY

THOMPSON RIVER SUBBASIN

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

IOWA AND MISSOURI

SCALE 0 1 2 3 4 5 6 7 8 MILES
0 2 4 6 8 10 12 KILOMETERS

SOURCE
SCS DRAWING 5,R 34,545 1 AND INFORMATION FROM SCS FIELD PERSONNEL
POLYCONIC PROJECTION

4-11-80
5,R-37,821

Table 62 -- Percent Flood Plain and Damage per Acre by Frequency of Recurrence, Hydrologic Unit 10280102, Northern Missouri River Tributaries Basin, Iowa and Missouri

States	Frequency* (Av. Yrs.)	Flood Plain (Av. %)	Damages Per Acre	
			Crop & Pasture	Total
			-----Av. $ per Acre-----	
Iowa	0.0-1	25	56	66
	1.1-2	41	26	34
	2.1-5	28	14	20
	5.1 or greater	6	3	7
Missouri	0.0-1	35	30	38
	1.1-2	5	17	22
	2.1-5	37	9	14
	5.1 or greater	23	3	3

* 0.0 to 1.0 - Floods more than once per year.
1.1 to 2.0 - Floods on the average between 1.1 to 2.0 years.
2.1 to 5.0 - Floods on the average between 2.1 to 5.0 years.
5.1 or greater - Floods on the average 5.1 years or greater.

Lower Grand River Subbasin (Hydrologic Units 10280103)

The Lower Grand River Subbasin has a drainage area 2,408 square miles, 125 square miles in Iowa and 2,283 square miles in Missouri (Table 63).

The present floodwater damages amount to $10.2 million annually (Table 64). The evaluated flood plain is estimated at 222,380 acres. Big Creek-Hurricane Watershed No. 14 is currently being planned under PL-566. In Missouri, active approved watershed applications exist for Medicine Creek, East-Yellow Creek, Upper Locust, and East Locust Creek watersheds.

Table 64 -- Average Annual Floodwater Damages, Lower Grand River Subbasin, Northern Missouri River Tributaries Basin, Iowa and Missouri

Item	Av. An. Floodwater Damages	
	1,000 dollars	Percent
Crop and pasture	8,376.1	82.2
Other agricultural	418.8	4.1
Sediment	118.7	1.2
Scour	1.5	
Road and bridge	345.5	3.4
Other	926.0	9.1
Total	10,186.6	100.0

Table 63 — Average Annual Floodwater Damage, Lower Grand River Subbasin, Hydrologic Unit 10280103, Northern Missouri River Tributaries Basin, Iowa and Missouri

No.	Watersheds Name	Drainage Area Sq. Mi.	Evaluated Flood Plain Acres	Average Annual Floodwater Damages							
				Crop and Pasture	Other Agr.	Agronomic Sediment Damages	Land damages Sediment	Land damages Scour	Road and Bridge	Other*	Total
				Dollars							
1	E. F. Medicine	170.7	5170	246120	12310				20110	27850	306390
2	Upper Locust	410.9	27050	858610	42930	18810	32350		42160	99490	1094350
3	Upper Medicine	217.0	17750	361510	18080	8030	490	1450	12310	40190	442060
4	East Locust	127.2	5200	113140	5660				11950	13070	143820
5	Lower Medicine	195.1	24770	933220	46660	19690	7840		13730	102110	1123250
6	Parsons Creek	118.4	6760	479510	23980				24030	52750	580270
7	Lower Locust	115.0	23950	1063940	53200				13200	113030	1243370
8	West Yellow	217.4	18140	654520	32720	14800	8950		48480	75950	835420
9	East Yellow	199.3	13190	219910	10990	5620	2080		31730	27040	297370
10	Turkey Creek	113.0	5570	195960	9800				35590	24140	265490
11	Lower Grand	161.9	900	18430	920				7660	2700	29710
12	Lower Yellow	24.7	5100	132390	6620				4470	14350	157830
13	Salt Creek	86.2	2250	125320	6270				16380	14800	162770
14	Big Creek	251.6	17290	779060	38960				60280	87830	966130
	L. Grand R. Mainstem		49290	2194470	109720				3430	230760	2538380
	Totals	2408.4	222380	8376110	418820	66950	51710	1450	345510	926060	10186610

* Certain losses resulting from flooding even though the property involved was not flooded.

Price base: Current normalized for agriculture (October 1976, WRC) 1970-74 crop yields

Damaging sediment deposits have been identified on 5,750 acres. The crop yield loss from damaging sediment varies from 3 to 13 percent. Sediment damages are estimated to be 100 percent recoverable in about one to five years with protection. Scour damages have been identified on 150 acres. Agronomic sediment deposition on 7,082 acres results from untimely sediment deposition on growing plants.

Two wildlife refuges, the State of Missouri's Fountain Grove Wildlife Refuge and the U.S. Fish and Wildlife Service's Swan Lake National Refuge, are adversely affected by sediment and flooding impairing their management practices. No monetary evaluation has been made of these damages during the inventory phase of the study.

The Lower Grand River Subbasin drains Land Resource Area 109, Iowa and Missouri heavy till plain. Flood plain land use is 76 percent cropland, 6 percent pastureland, 15 percent forest land and 3 percent other land.

A reach-frequency map (Map 25) was prepared to illustrate the variation in floodwater damages. In general, the more frequently a reach floods the greater the damages. The frequency of flooding has been related to the percent of flood plain flooded and damages per acre in Table 65.

Table 65 -- Percent Flood Plain and Damage per Acre by Frequency of Recurrence, Hydrologic Unit 10280103, Northern Missouri River Tributaries Basin, Iowa and Missouri

Frequency* (Av. yrs.)	Flood Plain (Av. %)	Damages per Acre	
		Crop & Pasture	Total
		-----Av. $ per Acre-----	
0.0-1	87.4	43	52
1.1-2	5.1	13	16
2.1-5	2.8	7	9
5.1 or greater	4.7	3	5

* 0.0 to 1.0 - Floods more than once per year.
1.1 to 2.0 - Floods on the average between 1.1 to 2.0 years.
2.1 to 5.0 - Floods on the average between 2.1 to 5.0 years.
5.1 or greater - Floods on the average 5.1 years or greater.

Chariton River Subbasin (Hydrologic Units 10280201, 10280202, and 10280203)

The Chariton River Subbasin contains three hydrologic unit areas as designated by the Water Resources Council (Map 19, page 96). This subbasin has a drainage area of 3,083 square miles, 907 square miles in Iowa and 2,176 square miles in Missouri.

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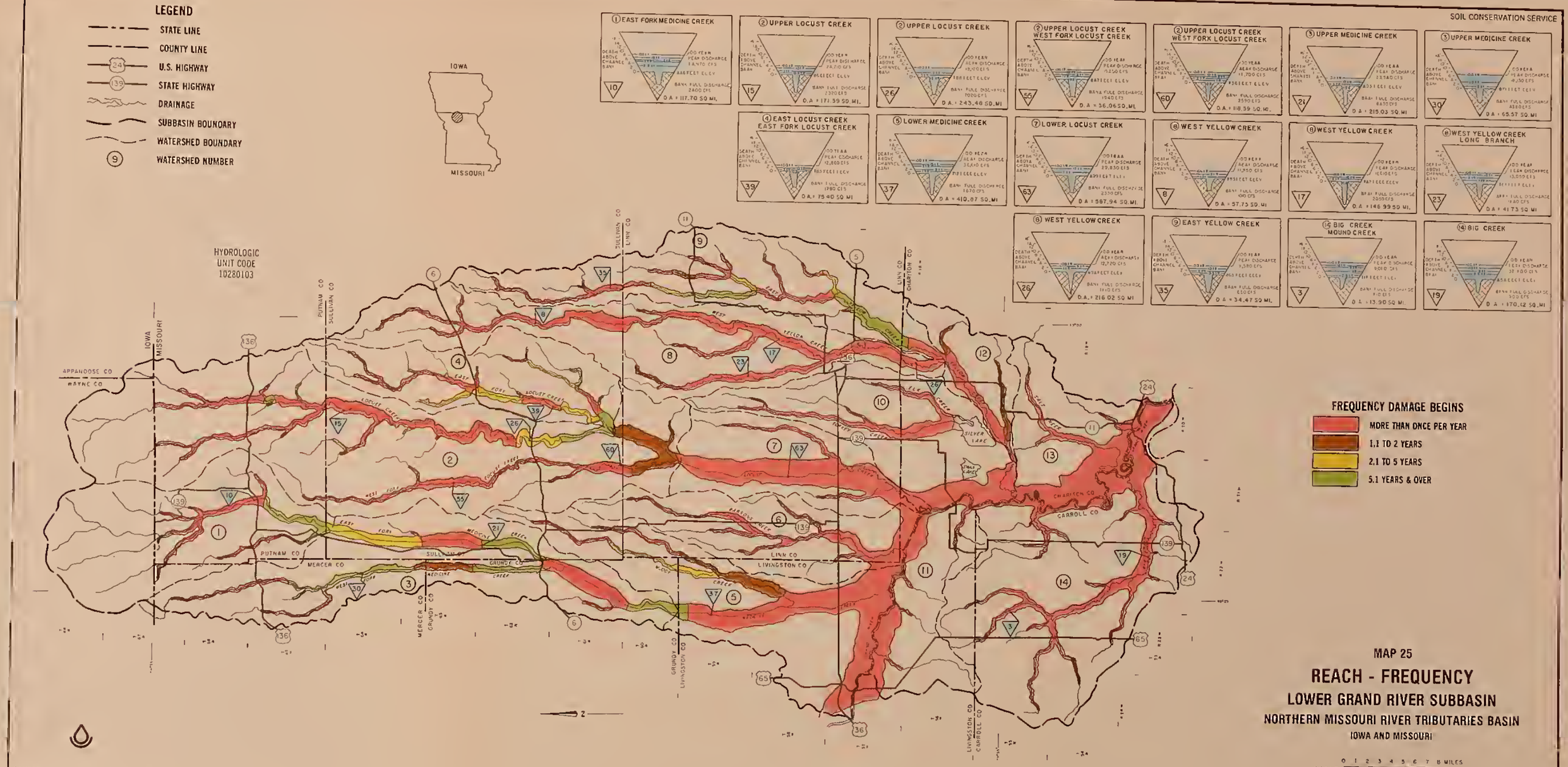

MAP 25

REACH - FREQUENCY

LOWER GRAND RIVER SUBBASIN

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

IOWA AND MISSOURI

SOURCE
SCS DRAWING 5,R-34,542 AND INFORMATION FROM SCS FIELD PERSONNEL
POLYCONIC PROJECTION

4-11-80
5,R-37,822

Subbasin	Hydrologic Unit Code	Drainage Areas Iowa	Missouri	Total
		------Square Miles-------		
Upper Chariton R.	10280201	907	439	1,346
Chariton R.	10280202	---	1,033	1,033
Little Chariton R.	10280203	---	704	704
Total		907	2,176	3,083

The present average annual floodwater damages in the Missouri portion of the Chariton River Basin amount to $4.8 million annually (Table 66).

Table 66 -- Average Annual Floodwater Damages, Chariton River Subbasin, Northern Missouri River Tributaries Basin, Iowa and Missouri

Item	Average Annual Floodwater Damages 1,000 dollars	Percent
Crop and pasture	3,829.2	79.0
Other agricultural	191.4	4.0
Agronomic sediment	73.9	1.5
Land sediment	36.5	0.7
Land scour	11.0	0.2
Roads and bridges	265.8	5.5
Other	440.8	9.1
Total	4,848.6	100.0

The total evaluated flood plain in the Missouri portion of the Chariton River Basin is estimated to be approximately 180,700 acres (Table 67).

Rathbun Lake, a Corps of Engineers project, is on the Upper Chariton River; the dam is located seven miles north of Centerville, Iowa. The Rathbun drainage area is 549 square miles. Impoundment was started November 21, 1969, and the lake filled to the multipurpose level October 10, 1970.

Upper Chariton River, Hydrologic Unit 10280201, Watersheds No. 1, 2, and 3 contribute drainage area to the lake. Watersheds No. 4, 5, 6, and 7 are Iowa tributaries to the Chariton River below Rathbun Lake. Some floodwater damage to crops and pastures occur along these tributaries, but the amount of damages has not been determined. Watershed No. 12, Wildcat-Blackbird Creek, has an active approved application for a PL-566 watershed.

The Chariton River, Hydrologic Unit 10280202, contains seven watersheds. Watershed No. 7, Bee Creek, has an active approved application for a PL-566 watershed. The Little Chariton River, Hydrologic Unit 10280203, contains four watersheds. The Middle Fork of Little Chariton Watershed No. 3 has an active proposed application for a PL-566 watershed.

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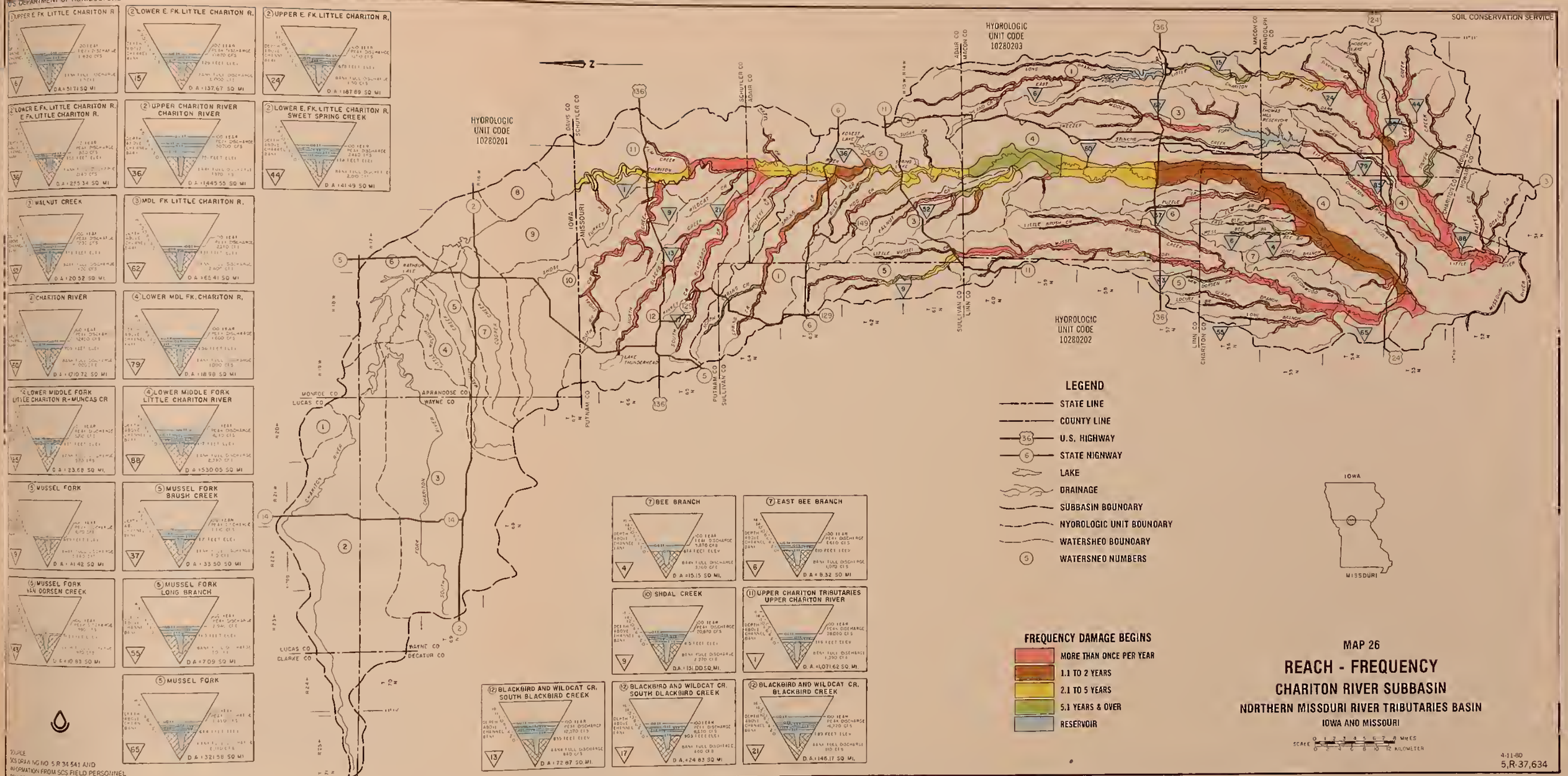


(1) UPPER E. FK LITTLE CHARITON R
D.A. = 51.75 SQ MI

(2) LOWER E. FK. LITTLE CHARITON R.
D.A. = 137.67 SQ MI

(2) UPPER E. FK LITTLE CHARITON R.
D.A. = 187.89 SQ MI

(2) LOWER E. FK. LITTLE CHARITON R. E. FK. LITTLE CHARITON R.
D.A. = 255.34 SQ MI

(2) UPPER CHARITON RIVER CHARITON RIVER
D.A. = 1,145.55 SQ MI

(2) LOWER E. FK. LITTLE CHARITON R. SWEET SPRING CREEK
D.A. = 141.49 SQ MI

(3) WALNUT CREEK
D.A. = 120.52 SQ MI

(3) MDL FK LITTLE CHARITON R.
D.A. = 365.41 SQ MI

(2) CHARITON RIVER
D.A. = 1,010.72 SQ MI

(4) LOWER MDL FK. CHARITON R.
D.A. = 118.98 SQ MI

(4) LOWER MIDDLE FORK LITTLE CHARITON R.-MUNCAS CR
D.A. = 23.68 SQ MI.

(4) LOWER MIDDLE FORK LITTLE CHARITON RIVER
D.A. = 530.05 SQ MI

(5) MUSSEL FORK
D.A. = 41.42 SQ MI

(5) MUSSEL FORK BRUSH CREEK
D.A. = 33.50 SQ MI

(5) MUSSEL FORK VAN DORSEN CREEK
D.A. = 10.83 SQ MI

(5) MUSSEL FORK LONG BRANCH
D.A. = 7.09 SQ MI

(5) MUSSEL FORK
D.A. = 321.58 SQ MI

(7) BEE BRANCH
D.A. = 15.15 SQ MI.

(7) EAST BEE BRANCH
D.A. = 8.32 SQ MI

(10) SHOAL CREEK
D.A. = 151.00 SQ.MI.

(11) UPPER CHARITON TRIBUTARIES UPPER CHARITON RIVER
D.A. = 1,071.62 SQ. MI.

(12) BLACKBIRD AND WILDCAT CR. SOUTH BLACKBIRD CREEK
D.A. = 72.87 SQ.MI.

(12) BLACKBIRD AND WILDCAT CR. SOUTH BLACKBIRD CREEK
D.A. = 24.83 SQ MI

(12) BLACKBIRD AND WILDCAT CR. BLACKBIRD CREEK
D.A. = 146.17 SQ MI.

MAP 26

REACH - FREQUENCY

CHARITON RIVER SUBBASIN

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

IOWA AND MISSOURI

4-11-80

5,R-37,634

DOUBLE SCORING NO. 5,R-34,541 AND INFORMATION FROM SCS FIELD PERSONNEL

POLYCONIC PROJECTION

Table 69 -- Average Annual Floodwater Damages, Direct Tributaries Subbasin, Northern Missouri River Tributaries Basin, Iowa and Missouri

Item	Average Annual Floodwater Damages	
	1,000 dollars	Percent
Crop and pasture	1,631.4	79.3
Other agricultural	81.6	3.9
Road and Bridge	158.0	7.7
Other damages	187.1	9.1
Total damages	2,058.0	100.0

The total evaluated flood plain is 49,684 acres (Table 70). No floodwater damages were evaluated in the Missouri River bottom alluvium.

William Creek Watershed No. 2 is a complete PL-566 watershed. Willow-Cravens Creek Watershed No. 5 is a PL-566 watershed approved for construction. Crooked River Watershed No. 6 has an active PL-566 approved application. Kinney-Rollins Watershed No. 4 and Wakenda Creek Watershed No. 7 have PL-566 applications which are no longer active. Although Shoal Creek Watershed No. 1 is situated in the greater Kansas City area of Liberty, Glenaire, Pleasant Valley, and Claycomo communities, no urban damages were evaluated. No significant flood plain land damages were identified in this subbasin.

Direct Tributaries Subbasin is situated in Land Resource Area 107, Iowa and Missouri deep loess hills, and Land Resource Area 109, Iowa and Missouri heavy till plain. Flood plain land use is 81 percent cropland, 8 percent pastureland, 9 percent forest land, and 2 percent other lands.

A reach-frequency map (Map 27) was prepared to illustrate the variation in floodwater damages. In general, the more frequently a reach floods the greater the damages. The frequency of flooding has been related to the percent of flood plain flooded and damages per acre in Table 71.

Table 71 -- Percent Flood Plain and Damage per Acre by Frequency of Recurrence, Hydrologic Unit 10300101, Northern Missouri River Tributaries Basin, Iowa and Missouri

Frequency* (Av. yrs.)	Flood Plain (Av. %)	Damages per Acre	
		Crop & Pasture	Total
		-----Av. $ per Acre-----	
0.0-1	74	39	49
1.1-2	15	11	16
2.1-5	5	7	10
5.1 or greater	6	2	3

* 0.0 to 1.0 - Floods more than once per year.
1.1 to 2.0 - Floods on the average between 1.1 to 2.0 years.
2.1 to 5.0 - Floods on the average between 2.1 to 5.0 years.
5.1 or greater - Floods on the average 5.1 years or greater.

Table 70 -- Average Annual Floodwater Damage, Direct Tributaries Subbasin, Hydrologic Unit 10300101, Northern Missouri River Tributaries Basin, Iowa and Missouri

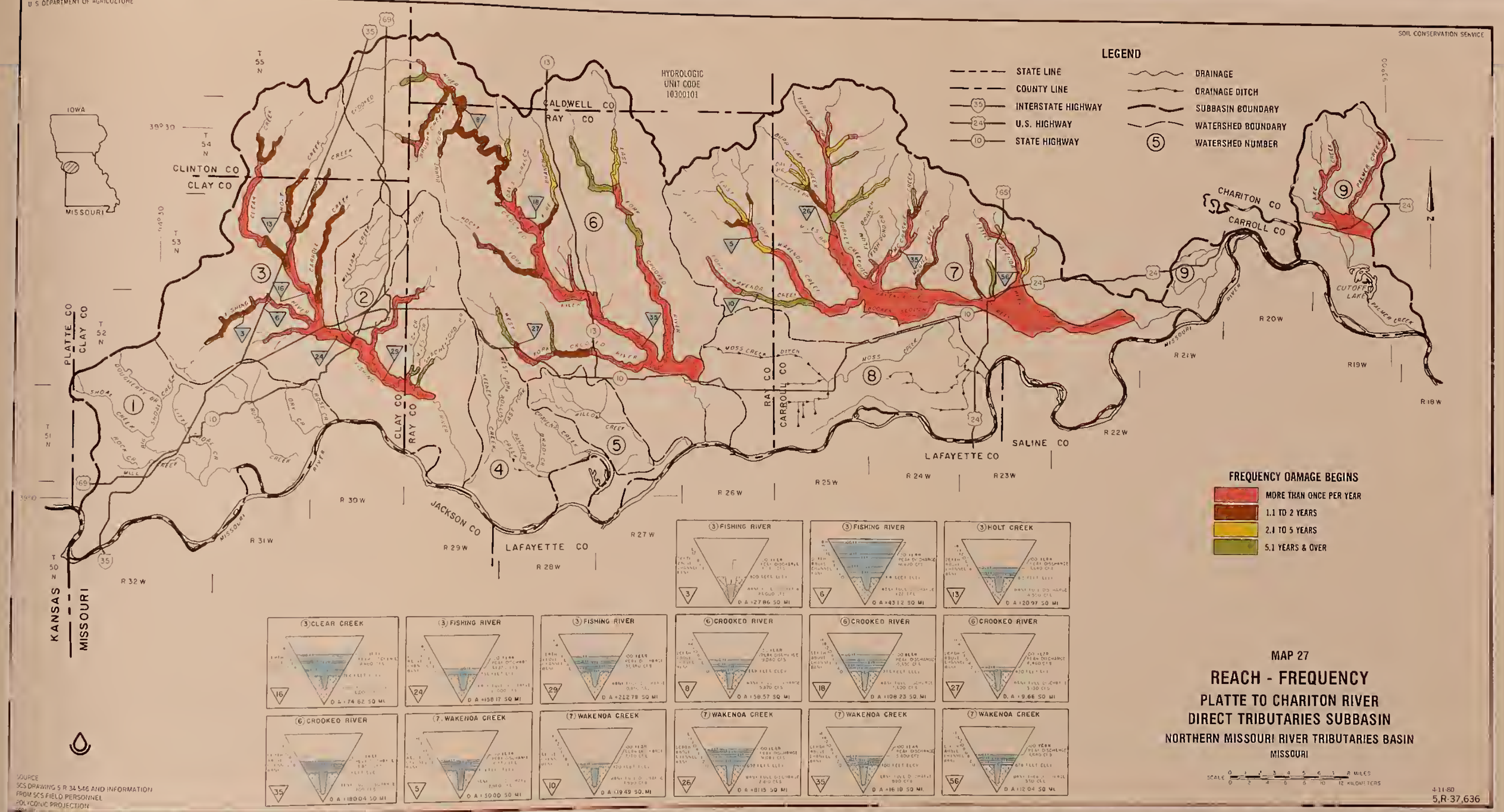
No.	Watersheds	Drainage Area Sq. Mi.	Average Annual Floodwater Damages: Flood Plain Acres	Crop and Pasture	Other Agr.	Road and Bridge	Sub-Total	Other*	Total
				dollars					
1	Shoal Creek	110.7	Agricultural damages insignificant						
2	William Creek	25.0	PL-566 completed watershed						
3	Fishing River	247.7	11879	426250	21310	42470	490030	49000	539030
4	Kinney Rollins	51.5	PL-566 not active						
5	Willow Creek	26.8	PL-566 approved for construction						
6	Crooked Creek	335.1	17681	348310	17420	28930	394660	39460	434120
7	Wakenda Creek	338.0	16990	675180	33760	63450	772390	77240	849630
8	Moss Creek	101.2	Missouri River bottom						
9	Palmer Creek	73.1	3134	181630	9080	23100	213810	21380	235190
	Missouri River bottom land	260.9							
	Totals	1570.0	49684	1631370	81570	157950	1870890	187080	2057970

* Certain losses resulting from flooding even though the property involved was not flooded.

Price base: Current normalized for agriculture (October 1976, WRC) 1970-74 crop yields.

U S DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE



MAP 27

REACH - FREQUENCY

PLATTE TO CHARITON RIVER DIRECT TRIBUTARIES SUBBASIN

NORTHERN MISSOURI RIVER TRIBUTARIES BASIN

MISSOURI

SOURCE
SCS DRAWING 5 R 34 546 AND INFORMATION FROM SCS FIELD PERSONNEL
POLYCONIC PROJECTION

4-11-80

5,R-37,636

Appendix B

G L O S S A R Y

Accelerated forestry program - An increased effort to accomplish forest land treatment measures, usually through PL-566 or RC&D Programs.

Accretion - The gradual addition of new land to old by the deposition of sediment carried by the water of a stream.

Acid runoff - Streamflow with a pH less than 7.0.

Acre-foot - The volume of water that will cover 1 acre to a depth of 1 foot.

Activity-day - Participation by an individual in a specific outdoor recreation activity during any part of a day. "Activity-occasion" is an interchangeable term with the same meaning.

Aesthetic appeal - The beauty or pleasure response from viewing desirable landscapes.

Afforestation - The artificial establishment of forest vegetation by planting or sowing on land that has not previously, or not recently, grown trees or shrubs.

Aggradation - The process of building up a surface by deposition. This is a long-term or geologic trend in sedimentation.

Agricultural land - Land in farms regularly used for agricultural production. The term includes all land devoted to crop or livestock enterprises, for example, the farmstead lands, drainage and irrigation ditches, water supply, cropland, and grazing land of every kind in farms.

Agronomic sediment damages (economic) - Sediment deposits on foilage reducing yields and causing additional tillage operation.

Algae bloom - Proliferation of living algae on the surface of lakes, streams, or ponds.

Alkali - In chemistry, any substance having marked basic properties in contradistinction with acid, that is being capable of furnishing to its solution or other substances the hydroxyl ion (OH negative). The important alkali metals are sodium and potassium. In a less scientific sense the term is applied to the soluble salts, especially the sulfates and chlorides of sodium, potassium, and magnesium and the carbonates of sodium, which are present in some soils of arid and semiarid regions in sufficient quantities to be detrimental to ordinary agriculture.

Alluvial - Pertaining to material that is transported and deposited by running water.

Alluvial soils - An azonal great soil group of soils, developed from transported and relatively recently deposited material (alluvium) characterized by a weak modification (or none) of the original material by soil-forming processes.

Alluvium - A general term for all detrital material deposited or in transit by streams, including gravel, sand, silt, clay, and all variations and mixtures of these. Unless otherwise noted, alluvium is unconsolidated.

Aquatic - Pertaining to water; living or frequenting water.

Aquifer - A geologic formation or structure that transmits water in sufficient quantity to supply the needs for a water development. The term waterbearing is sometimes used synonymously with aquifer when a stratum furnishes water for a specific use. Aquifers are usually saturated sands, gravel, fractures, cavernous and vesicular rock.

Average annual flood damages - Expression of damage values as a uniform annual series that considers the nonuniform rate of damage accrual. Each yearly damage is reduced to its present worth, and the sum of these present worths is spread uniformly over the period of analysis.

Basal area (forestry) - The area of the cross section at breast height of a single tree or of all the trees in a stand, usually expressed by square feet. This may be measured inside or outside the bark, usually the latter, (range) - The area of ground surface covered by the stem or stems of a range plant, usually measured 1 inch above the soil in contrast to the full spread of the foliage.

Base flow - The stream discharge from ground water.

Baseline (economics) - Denotes a reference line or point or a statistical framework from which to begin a planning action. A base period of 1970 to 1974 was used in this report.

Basic employment - Employment in industries within a specified area which produces a volume that is transported and sold in other areas.

Basin (hydrology) - The area drained by a river; (irrigation) - A level plot or field, surrounded by dikes, which may be flood irrigated.

Bedload - The sediment that moves by sliding, rolling, or bounding on or very near the streambed.

Bedrock - The solid rock underlying soils and the regolith in depths ranging from zero (where exposed by erosion) to several hundred feet.

Biota - The flora and fauna of a region.

Board foot - A unit of measure of the wood in lumber, logs, bolts, or trees; it is the amount of wood in a board 1 foot wide, 1 foot long, and 1 inch thick before surfacing or other finishing. Abbr. bd. ft.

Browse - Twigs or shoots, with or without attached leaves, of shrubs, trees, or woody vines available as forage for domestic and wild browsing animals.

Buffer strips - Strips of grass or other erosion-resisting vegetation between or below cultivated strips or fields.

Calcium bicarbonate stream - A stream in which the predominant cation is calcium and the predominant anion bicarbonate.

Calcium sulfate stream - A stream in which the predominant cation is calcium and the predominant anion is sulfate.

Canopy - The cover of leaves and branches formed by the tops or crowns of plants.

Carbonaceous - Pertaining to or containing carbon derived from plant and animal residues.

Census of Agriculture - A census taken by the Bureau of Census every 5 years. It includes number of farms, land in farms, crop acreage and production, livestock numbers and production, farm spending, farm facilities and equipment, farm tenure, value of farm products sold, farm size, etc. Data are given for states and counties.

Central feed grain and livestock region - Commonly called the corn belt, an outstanding grain-producing region of the world. This land area delineated by land resource areas, includes all of the State of Iowa and parts of the States of Missouri, South Dakota, Minnesota, Michigan, Illinois, Ohio, Kentucky, Nebraska, Kansas, and Oklahoma.

Channel - A natural stream that conveys water; a ditch or channel excavated for the flow of water.

Channel improvement - The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining, or other means in order to increase its capacity. Sometimes used to connote channel stabilization.

Channel stabilization - Erosion prevention and stabilization of velocity distribution in a channel using jetties, drops, revetments, vegetation, and other measures.

Cherty - An adjective incorporated into the soil textural class designations of horizons when the soil mass contains between 15 and 90 percent by volume of chert fragments. See chert fragments and coarse chert fragments as defined under coarse fragments.

Claypan - A dense, compact layer in the subsoil having a much higher clay content than the overlying material from which it is separated by a sharply defined boundary; formed by downward movement of clay or by synthesis of clay in place during soil formation. Claypans are usually hard when dry and plastic and sticky when wet. They usually impede the movement of water and air. With adequate fertility they often do not impede plant roots. See hardpan.

Clearcutting (forestry) - A method of cutting that removes the entire timber stand on the area cut. Contrast with selective cutting.

Climate, continental - The type of climate characteristic of land areas separated from the moderating influence of oceans by distance, direction, or mountain barriers, marked by relatively large daily and seasonal change in temperature.

Climax vegetation - Relatively stable vegetation in equilibrium with its environment and with good reproduction of the dominant plants.

Coal gasification plant - A plant constructed to convert coal to gas.

Commercial forest land - Forest land that is producing or is capable of producing crops of industrial wood and is not withdrawn from timber utilization by statute or administrative regulation.

Continental glaciers - Glaciers which are not confined to valleys but spread over wide tracts of country, like the ice caps of Greenland and the Antarctic region. Continental glaciers were most widespread in the glacial periods of the Pleistocene era.

Cool-season plant - A plant that makes its major growth during the cool portion of the year, primarily in the spring but in some localities in the winter.

Cord - A unit of measurement of stacked wood containing 128 cubic feet within its outside surfaces. The standard cord is a pile of wood 4 feet by 8 feet, made up of sticks 4 feet long.

Cost allocation - The process of apportioning cost among the various purposes served by a measure or work of improvement.

Cover (wildlife) - Plants or objects used by wild animals for nesting, rearing of young, resting, escape from predators, or protection from adverse environmental conditions.

Cretaceous - A geologic time unit and rocks formed during this time. Approximately 100 million to 70 million B.C.

Cropland - Land in tillage, rotation, and orchards. Land use was classified according to findings at the time of inspection. Land in winter cover crops following cotton, corn, soybeans, etc., was classed on the basis of the preceding crop.

Cubic foot per second - Rate of fluid flow at which 1 cubic foot of fluid passes a measuring point in 1 second. Abbr. cfs. Syn. Second-foot; CUSEC.

Cultural types - A sterotyping or grouping of past cultures by archeologists.

D.B.H. - Diameter breast high; the diameter of the bole of a tree at $4\frac{1}{2}$ feet above the average ground level.

Deciduous plant - A plant that sheds all its leaves every year at a certain season.

Decreaser plant species - Plant species in the original vegetation that will decrease in relative amount with continued overuse, often termed decreasers.

Degradation - To wear down by erosion, especially through stream action.

Deposit - Material left in a new position by a natural transporting agent, such as water, wind, ice, or gravity, or by the activity of man.

Deposition - The accumulation of material dropped because of a slackening movement of the transporting agent - water or wind.

Desirable trees - Growing-stock trees having no serious defects in quality that limits present or prospective use. These are trees that would be favored by forest managers in silvicultural operations because of greater commercial value.

Discharge (hydraulics) - Rate of flow, specifically fluid flow; a volume of fluid passing a point per unit time, commonly expressed as cubic feet per second, million gallons per day, gallons per minute, or cubic meters per second.

Dissolved oxygen - The amount of oxygen gas dissolved in water. It is commonly expressed in mg/1. The solubility of oxygen varies inversely with temperature, the higher the temperature the less oxygen can be dissolved in the water.

Dissolved solids - The total amount of dissolved material, organic and inorganic, contained in water or wastes. Excessive dissolved solids make water unpalatable for drinking and unsuitable for industrial uses.

Diversion - Channel constructed across the slope for the purpose of intercepting surface runoff; changing the accustomed course of all or part of a stream. See terrace.

Diversion terrace - Diversions, which differ from terraces in that they consist of individually designed channels across a hillside, may be used to protect bottom land from hillside runoff or may be needed above a terrace system for protection against runoff from an unterraced area. They may also divert water out of active gullies, protect farm buildings from runoff, reduce the number of waterways, and are sometimes used in connection with stripcropping to shorten the length of slope so that the strips can effectively control erosion. See terrace.

Diversity - The variety of species within a given association of organisms. Areas of high diversity are characterized by a great variety of species; usually relatively few individuals represent any one species. Areas with low diversity are characterized by a few species; often relatively large numbers of individuals represent each species.

Dominant species - Species of a community which are controlling and often the most abundant.

Drainage (1) - The removal of excess surface water or ground water from land by means of surface or subsurface drains, (2) - Soil characterisitics that affect natural drainage.

Drainage district - A cooperative, self-governing public corporation created under state law to finance, construct, operate, and maintain a drainage system involving a group of land holdings.

Drift, glacial - Rock debris transported by glaciers and deposited either directly from the ice or from the meltwater. The debris may or may not be heterogenous.

Ecological quality - A diversity of plant and animal species that provide an energy balanced ecosystem.

Ecosystem - Energy-driven complex of a community of organisms and its controlling environment.

Edge (wildlife) - The transitional zone where one cover type ends and another begins.

Edge Index (E.I.) - Reflects the numerical rating value for wildlife (quail) of edgelands. A value derived from the average numerical value of the edge parameter(s) per transect mile x the H.D.I. of the parameter(s) per transect mile.

Effluent (1) - The discharge or outflow of water from ground or sub-surface storage; (2) - The fluids discharged from domestic, industrial, and municipal waste collection systems or treatment facilities.

Environment - The sum total of all the external conditions that may act upon an organism or community to influence its development or existence.

Environmental corridors - Linear water-oriented areas reserved for managed use and maintained or left in or developed to a condition that can enhance man's environment.

Ephemeral stream - A stream or portion of a stream that flows only in direct response to precipitation. It receives little or no water from springs and no long continued supply from snow or other sources. Its channel is at all times above the water table.

Erosion -

Accelerated erosion - Erosion much more rapid than normal, natural, or geologic erosion, primarily as a result of the influence of the activities of man or, in some cases, of other animals or natural catastrophies that expose base surfaces, for example, fires.

Geological erosion - The normal or natural erosion caused by geological processes acting over long geologic periods and resulting in the wearing away of mountains, the building up of flood plains, coastal plains, etc. Syn. natural erosion.

Gully erosion - The erosion process whereby water accumulates in narrow channels and, over short periods, removes the soil from this narrow area to considerable depths, ranging from 1 to 2 feet to as much as 75 to 100 feet.

Natural erosion - Wearing away of the earth's surface by water, ice, or other natural agents under natural environment conditions of climate, vegetation, etc., undisturbed by man. Syn. geological erosion.

Normal erosion - The gradual erosion of land used by man which does not greatly exceed natural erosion. See natural erosion.

Rill erosion - An erosion process in which numerous small channels only several inches deep are formed; occurs mainly on recently cultivated soils. See rill.

Sheet erosion - The removal of a fairly uniform layer of soil from the land surface by runoff water.

Evapotranspiration - Water transpired by vegetation plus that evaporated from the soil. Syn. consumptive use.

Externalities (pecuniary) - Relates to changes in income of firms economically related to direct and indirect uses of project output.

Fauna - The animal life of a region.

Federal land - Includes military installations, national forests, national wildlife refuges, hospitals, and other federally owned land outside urban and built-up areas.

Fiberboard - Reconstituted wood that was first reduced to small fractions and then put back together by special forms of manufacture into panels of relatively large size and moderate thickness.

Flood - An overflow or inundation that comes from a river or other body of water and causes or threatens damage.

Flood control - Methods or facilities for reducing flood flows.

Flood control project - A structural system installed for protection of land and improvements from floods by the construction of dikes, river embankments, channels, or dams.

Flood peak - The highest value of the stage or discharge attained by a flood, thus, peak stage or peak discharge.

Flood plain - Nearly level land situated on either side of a channel which is subject to overflow flooding.

Flood plain deposition - The deposit of sediments by floodwaters on flood plains.

Flood stage - The stage at which overflow of the natural banks of a stream begins to cause damage in the reach in which the elevation is measured.

Floodwater or flood damage - The economic loss caused by floods, including damage by inundation, erosion, scour, or sediment deposition on flood plain areas. Floodwater damages result from physical damages or losses, emergency, costs, and business or financial losses. Evaluation may be based on the cost of replacing, repairing, or rehabilitating; the comparative change in market or sales value; or the change in income or production caused by flood experience.

Flora - The sum total of the kinds of plants in an area at one time.

Forage - All browse and herbaceous food that is available to livestock or game animals, used for grazing or harvested for feeding.

Forb - A herbaceous plant which is not a grass, sedge, or rush.

Forest land - Lands which are (a) at least 10 percent stocked by forest trees of any size and capable of producing timber or other wood products, or capable of exerting an influence on the water regime; (b) lands from which the trees have not been developed for other uses; or (c) afforested (planted) areas. "Soil bank" lands planted to trees are included here. Land freshly clearcut and smoothed for cropland or pasture is considered developed for other uses (see "b" above) and was reported under the use anticipated.

Commercial - Forest land which is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulations. This includes areas suitable for management to grow crops of industrial wood generally of site quality capable of producing in both accessible and operable areas and prospectively operable and accessible areas.

Noncommercial - Unproductive forest land incapable of yielding crops of industrial wood because of adverse site conditions and productive forest land withdrawn from commercial timber through statute or administrative regulation, such as state parks or wildlife refuges which would be known locally.

Forest land grazed - Acreage of commercial or noncommercial forest grazed by livestock.

Forest management - The application of business methods and technical forestry principles to the operation of a forest property.

Forest type - A tract of forest land in which one or more predominate species make up a specified proportion of the stand.

Fragipan - A natural subsurface horizon with high bulk density relative to the solum above, seemingly cemented when dry but showing a moderate to weak brittleness when moist. The layer is low in organic matter, mottled, slowly or very slowly permeable to water, and usually shows occasional or frequent bleached cracks forming polygons. It may be found in profiles of either cultivated or virgin soils but not in calcareous material.

Frequency - A statistical expression of the presence or absence of individuals of a species in a series of subsamples, that is, the ratio between the number of sample areas that contains a species and the total number of sample areas.

Fuelwood - Fireplace wood. An average family uses 1 to 1½ cords per year.

Furbearer - A mammal sought for its fur.

Gage or gauge - Device for registering precipitation, water level, discharge, velocity, pressure, temperature, etc.

Gaging station - A selected section of a stream channel equipped with a gage, recorder, or other facilities for determining stream discharge.

Game animal - An animal sought for its fur, flesh, or trophy value, or one so defined by law.

Glaciofluvial deposits - Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and may occur in the form of outwash plains, deltas, kames, eskers, and kame terraces. See glacial drift, till.

Going programs - The non-accelerated cooperative programs with federal, state, and local governments, forest industries, and private landowners, for purposes of protection, management, and use of forest and their products.

Grade stabilization structure - A structure for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further head-cutting or lowering of the channel grade.

Grassland - Land on which the existing plant cover is dominated by grasses. See natural grassland.

Grazing control - The managed regulation of the eating of any kind of standing vegetation by domestic livestock or wild animals by fencing.

Gross income (economics) - The monetary value of all agricultural products grown in the study area times their respective projected price per unit.

Gross soil loss - The sum dislodgement of soil by all types of erosion.

Ground water - Phreatic water or subsurface water in the zone of saturation.

Growing stock - The sum, by number or volume, of all the live trees in a forest or a specified part of it.

Gully - A channel or miniature valley cut by concentrated runoff but through which water commonly flows only during and immediately after heavy rains or during the melting of snow. A gully may be dendritic or branching or it may be linear, rather long, narrow, and of uniform width. The distinction between gully and rill is one of depth. A gully is sufficiently deep that it would not be obliterated by normal tillage operations, whereas a rill is of lesser depth and would be smoothed by ordinary farm tillage. Syn. Arroyo. See erosion; rill.

Habitat - The environment in which the life needs of a plant or animal are supplied.

Habitat Diversity Index (H.D.I.) - As used in the Missouri Habitat studies, the Habitat Diversity Index is a figure reflecting the number of vegetative type - edge changes encountered per mile of transect study.

Hard - 121 to 180 mg/l of $CaCO_3$; Very hard - more than 180 mg/l of $CaCO_3$.

Hardness - Hardness of water is commonly defined in terms of equivalents of $CaCO_3$; soft - 0 to 6- mg/l of $CaCO_3$; moderately hard - 61 to 120 mg/l of $CaCO_3$; hard - 121 to 180 mg/l of $CaCO_3$; very hard - more than 180 mg/l of $CaCO_3$.

Headwater - (1) The source of a stream; (2) The water upstream from a structure or point on a stream.

Heavy soil - A commonly used term to describe various fine-textured soils.

Humid - A term applied to regions or climates where moisture, when distributed normally throughout the year, should not be a limiting factor in the production of most crops. The lower limit of precipitation under cool climates may be as little as 20 inches annually. In hot climates, it may be as much as 60 inches. Natural vegetation is generally forest. Contrast with sub-humid.

Hydrologic Unit - Hydrologic units are drainage area boundaries established by member agencies of the U.S. Water Resources Council (WRC) and the responsible water resource agencies in each state.

Increaser plant species - Plant species of the original vegetation that increase in relative amount, at least for a time, under overuse. Commonly termed increasers.

Infiltration - The flow of a liquid into a substance through pores or other openings, connoting flow into a soil in contradistinction to the work percolation which connotes flow through a porous substance.

Installation cost - The monetary cost of physically performing project measures, i.e., tree planting labor cost.

Interspersion Index (I.I.) - The average numerical value of parameter(s) per transect mile x the H.D.I. (Habitat Diversity Index).

Interspersion (wildlife) - The distribution of heterogeneous cover types and plant species in a limited area.

Invader plant species - Plant species that were absent in undisturbed portions of the original vegetation and will invade under disturbance or continued overuse. Commonly termed invaders.

Kansan glaciation - A glacial age in the Pleistocene era. Younger than Nebraskan and older than Wisconsin and Illinoisian approximately 600 to 500 Thousand B.C.

Lagoon, sewage - Ponding effluent for septic action.

Land Capability Class - One of the eight classes of land in the land capability classification of the Soil Conservation Service. These eight land capability classes, distinguished according to the risk of land damage or the difficulty of land use, are:

—Land suitable for cultivation and other uses.

1. Soils in class I have few limitations that restrict their use.
2. Soils in class II have some limitations that reduce the choice of plants or require moderate conservation practices.
3. Soils in class III have severe limitation that reduce the choice of plants or require special conservation practices, or both.
4. Soils in class IV have very severe limitations that restrict the choice of plants, require very careful management, or both.

—Land generally not suitable for cultivation (without major treatment).

5. Soils in class V have little or no erosion hazard but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.
6. Soils in class VI have severe limitations that make them generally unsuited for cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.
7. Soils in class VII have very severe limitations that make them unsuited to cultivation and that restricts their use largely to grazing, woodland, or wildlife.
8. Soils and landforms in class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, water supply, or aesthetic purposes.

Land adequately managed or treated - This group includes all land on which the use, management, and treatment meets the minimum standards of the conservation programs of the SCS, the Soil Conservation Districts, the Indian Service, or of the Federal Land Management Agency concerned. It includes all types of management, vegetation, and mechanical practices.

Land damages (economic) - Loss of productivity from flood plain scour, sediment deposition and an impairment of drainage commonly called swamping.

Land easement - The payment to the landowner for the right or privilege in respect to a specific use or enjoyment by another person for the benefit of another thing.

Land resource area - An area of land reasonably alike in its relationship to agriculture with emphasis on combinations and/or intensities of problems in soil and water conservation, ordinarily larger than a land resource unit and smaller than a land resource region.

Land resource areas - Broad, geographic areas having similar soil, climatic, geologic, vegetative, and topographic features.

Land resource region - A generalized grouping of land resource areas reflecting regional relationships to agriculture with emphasis on soil and water conservation.

Land resource unit - A subdivision of a land resource area with emphasis on a specialized type of agriculture, intensities, or problems in soil and water conservation. It has a narrower range in relationship to agriculture with emphasis on soil and water conservation.

Land treatment measure - In forestry, reference to the practice necessary to improve watershed protection or increase forest resources.

Legume - A member of the legume or pulse family, LEGUMINOSAE. One of the most important and widely distributed plant families. The fruit is a "legume" or pod that opens along two sutures when ripe. Flowers are usually papilionaceous (butterfly-like). Leaves are alternate, have stipules, and are usually compound. Includes many valuable food and forage species, such as the peas, beans, peanuts, clovers, alfalfas, sweet clovers, lespedezas, vetches, and kudzu. Practically all legumes are nitrogen-fixing plants.

Light soil - A coarse-textured soil with a low drawbar pull and, hence, easy to cultivate. See coarse texture; soil texture.

Linear water - Oriented areas with a combination of resources such as forest, wildlife, and recreation that has the potential to enhance man's environment.

Loamy - Intermediate in texture and properties between fine-textured and coarse-textured soils. Includes all textural classes with the word "loam" as a part of the class name, such as clay loam. See loam; soil texture. See particle size classes for family groupings for its use in the Soil Classification System of the National Cooperative Soil Survey in the United States.

Loess - Material transported and deposited by wind and consisting of predominantly silt-sized particles.

Low BTU gas - Produced from coal. This gas was once widely used as furnace fuel but has been replaced over the years by low-cost, clean natural gas. A potential commercial fuel source in the immediate area of production.

Major Land Resource Areas (MLRA's) - Broad geographic areas having similar soil, climate, geologic, vegetative, and topographic features.

Mantle - Short for mantle rock. The covering of uncombined fragments of rock, soil, and other materials that form the earth's surface layer.

Marketable forest products - The products or outputs of forest land that can be sold or used on farm, i.e., fence posts or sawlogs.

Marsh - Periodically wet or continually flooded area with the surface not deeply submerged. Covered dominantly with sedges, cattails, rushes, or other hydrophytic plants. Sub-classes include freshwater and saltwater marshes. See swamp; miscellaneous land type.

Meadow - An area of natural or planted vegetation dominated by grasses and grasslike plants used primarily for hay production.

Mean (statistics) - The average of a group of items obtained by adding together all items and dividing by the total number of items used.

Mississippian - A geologic time unit and rocks formed during this time. Older than Pennsylvanian, approximately 250 to 230 Billion B.C.

Multi-cropping - A management technique in which walnuts, timber, hay and pasture might be produced from a given acre.

Native species - A species that is a part of an area's original fauna or flora.

Natural grassland - An area in which the natural potential plant community is dominated by grasses and grasslike plants. Associated species include forbs and woody plants.

Natural scenic area - Area with exceptional scenery, fauna or flora, and geological or mineral interest, with or without minimum development for access.

Net annual growth of growing stock - The annual change in volume of sound wood in live sawtimber and poletimber trees during a specified period resulting from natural causes.

Net Returns (economics) - Gross income less production costs represents the returns to land, management, risk, and unallocated overhead.

Niche (wildlife) - The place in the plant or animal community that a species may occupy.

Non-commercial forest land - Forest land, such as state parks, that qualifies as commercial forest, but is withdrawn from timber utilization through statute, ordinance, or administrative order; or forest land that is incapable of yielding a stand averaging at least one 13 foot sawlog per tree.

Nonstocked - Areas of commercial forest land on which stocking of growing stock trees is less than 10 percent.

Nut production - The amount of black walnut nuts grown each year.

Nutrients - (1) Elements, or compounds, essential as raw materials for organism growth and development, such as carbon, oxygen, nitrogen, phosphorus, etc.; (2) The dissolved solids and gasses of the water of an area.

Odd area (wildlife) - A small area of land, such as a bare knob, fence corner, sink hole, blow-out, borrow pit, or an irregularly shaped area, that may be best used to produce wildlife habitat.

Operation and maintenance costs - Average annual costs of project operation and normal maintenance.

Other damages (economic) - Includes certain losses which result from flooding even though the property involved was not flooded. Other damages were estimated at 10 percent of direct damages.

Other land - Nonfederal rural land not classified as cropland, pasture, and range, forest woodland, or urban and built-up.

In farms - Other land considered locally as part of a farm. It includes farmsteads, farm roads, feedlots, and other service areas, ditchbanks, fence and hedgerows, and miscellaneous areas which do not fit into uses defined in this section. In farms also includes marshland not used for pasture, range, cropland, or forest. Although a small portion of this acreage would be suitable for range, the principal land use is for wildlife.

Not in farms - Other nonfederal rural land which is not part of a farm. It may include rural nonfarm residences and the acreage (except forest land) considered a part of such residences and investment tracts. It also includes areas as defined for urban and built-up that are less than 10 acres in size, gravel pits and borrow pits.

Outdoor recreation carrying capacity - The number of people an area or facility can handle at a given time without resource damage.

Outdoor recreation demand - A measure of outdoor recreation participation in activity-days or recreation-days, given a certain set of socio-economic and opportunity conditions.

pH - A numerical measure of acidity or hydrogen ion activity. Neutral is pH 7.0. All pH values below 7.0 are acid, and all above 7.0 are alkaline.

Parent materials - The horizon of weathered rock or partly weathered soil material from which the soil is formed.

Pasture - Land in grass or other long-term forage growth that is used primarily for grazing. This does not include rotation pasture or cropland defined above. Pasture may have been occasionally used for field crops if the frequency was less than one year in seven or may have been periodically renovated, with ryegrass, wheat, oats, etc., for grazing. The land may contain shade trees or scattered timber trees with less than 10 percent canopy but the principal plant cover is such as to identify its use as permanent grazing land.

Peak discharge - See flood peak.

Pennsylvanian - A geologic time unit and rocks formed during this time. Younger than Mississippian, approximately 230 to 215 Billion B.C.

Per capita income - The total personal income accruing to the residents of an area divided by the resident population of that area.

Percolation, soil water - The downward movement of water through soil, especially the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 or less.

Permeability - Capacity for transmitting a fluid. It is measured by the rate at which a fluid of standard viscosity can move through material in a given interval of time under a given hydraulic gradient.

Plant succession - The process of vegetation development whereby an area becomes successively occupied by different plant communities of higher ecological order.

PL-46 - The establishing and enabling act of the Soil Conservation Service Public Law 46 - 74th Congress, 49 Stat. 163, 164 (16 U.S.C. 590a-590f) was approved on April 27, 1935. This act directed the Secretary of Agriculture to establish an agency to be known as the "Soil Conservation Service" to exercise the powers conferred on him by the act.

PL-566 - The Watershed Protection and Flood Prevention Act (Public Law 566 -83d Congress) was approved. The act authorized a permanent program by which the Department of Agriculture provides technical and financial assistance to local watershed groups willing to assume responsibility for initiating, carrying out, and sharing the costs of upstream watershed conservation and flood control.

Pleistocene valleys - Valleys carved into the underlying bedrock by streamflow during the Pleistocene era.

Poletimber size class - Live merchantable hardwood tree species between 5.0 inches and 10.9 d.b.h.

Poletimber stands - Stands failing to meet specifications for sawtimber but at least 10 percent stocked with trees 5.0 inches d.b.h. or larger with at least half of the minimum stocking in poletimber-size trees.

Pollution, water - Any change in the character of water adversely affecting its usefulness.

Potential plant community - See climax vegetation.

Prime, unique, and important farmlands - Lands having certain desirable combinations of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and are available for these uses. See Federal Register Notice dated January 31, 1978, for complete definitions.

Production cost (economics) - The monetary value of fixed and variable cost of growing a crop.

Pulpwood - Wood products that could be ground up into pulp for the making of paper or chip products.

Recreation-day - A visit by an individual to a recreation area for recreation purposes during a significant portion or all of a 24-hour day.

Recreation demands - The quantity of recreation demanded at existing user prices, some of which are near zero.

Recreation visit - A visit by an individual to a recreation area for recreation purposes during a significant portion or all of a 24-hour day. Syn. Recreation-day.

Reforestation - Restocking an area with forest trees.

Reservoir - A pond, lake, or basin, either natural or artificial, for the storage, regulation, and control of water.

Multiple-purpose reservoir - A reservoir planned to be used for more than one purpose.
Retarding reservoir - Ungated reservoir for temporary storage of floodwater. Sometimes called a detention reservoir.
Single-purpose reservoir - A reservoir planned to be used for only one purpose.

Residual - Short for residual soil. Soil formed in place by the disintegration and decomposition of rocks and the consequent weathering of the mineral materials. Presumably developed from the same kind of rock as that on which it lies.

River basin plan - A plan for development of water and related land resources to make the best use of such resources to meet the basin needs and make the greatest long-term contribution to the economic growth and social well-being of the people of the basin and the nation.

Rough fish - Those species of fish considered to be of either poor fighting quality when taken on tackle or of poor eating quality. Most species in this group are more tolerant of widely changing environmental conditions than are game fish.

Runoff (hydraulics) - That portion of the precipitation on a drainage area that is discharged from the area in stream channels. Types include surface runoff, ground water runoff, or seepage.

Sawtimber size class trees - Live merchantable trees 11.0 inches diameter, breast height and larger.

Sawtimber stands - Stands having a minimum net volume in live merchantable sawtimber trees of commercial species of 1,500 board feet per acre, International $\frac{1}{4}$ inch rule.

Sawtimber volume - Net volume in board feet, International $\frac{1}{4}$ inch rule of merchantable sawlogs in live sawtimber trees. Net volume equals gross volume less deductions for rot, sweep, and other defects that affect use for lumber.

Sediment deposition - The deposit of sediments in lakes, streams, channels, on flood plains, etc.

Sediment Yield - The total amount of eroded materials delivered to a given point in a natural watershed.

SCORP - State Comprehensive Outdoor Recreation Plan.

Scour - To abrade and wear away. Used to describe the wearing away of terrace or diversion channels or streambeds.

Sediment - Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Sediment discharge - The quantity of sediment, measured in dry weight or by volume, transported through a stream cross section in a given time. Sediment discharge consists of both suspended load and bedload.

Sedimentary rocks - Formed by lithification of sediments, mechanical, chemical, or organic. Two broad categories are clastic and chemical.

Seedlings and saplings - Trees less than 5.0 inches d.b.h. with no merchantable value.

Site (ecology) - (1) An area considered for its ecological factors with reference to capacity to produce vegetation; the combination of biotic, climatic, and soil conditions of an area; (2) An area sufficiently uniform in soil, climate, and natural biotic conditions to produce a particular climax vegetation.

Site index (forestry) - A numerical expression commonly accepted as an indicator of the quality or timber productivity of a site. It is an expression of the height-age relationship of the tallest trees (dominants and codominants) in normal stands at some designated age, such as 50 years.

Soil - (1) The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants; (2) The unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate (including moisture and temperature effects), macro- and micro-organisms, and topography, all acting over a period of time and producing a product—soil—that differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics; (3) A kind of soil is the collection of soils that are alike in specified combinations of characteristics. Kinds of soil are given names in the system of soil classification. The terms "the soil" and "soil" are collective terms used for all soils, equivalent to the word "vegetation" for all plants.

Soil loss - The dislodgement of soil.

Soil survey - A general term for the systematic examination of soils in the field and in laboratories; their description and classification; the mapping of kinds of soil; the interpretation of soils according to their adaptability for various crops, grasses, and trees; their behavior under use or treatment for plant production or for other purposes; and their productivity under different management systems.

Solids, dissolved - Solids that are dissolved in (sewage). None of the dissolved solids are settleable.

SRG's - Soil Resource Groups. A composite of soil capability classes with similar erosion potentials.

Stabilized grade - The slope of a channel at which neither erosion nor deposition occurs.

Stand - An aggregation of trees or woody vegetation occupying an area of 1 acre or more.

State soil conservation committee, commission, or board - The state agency established by the state soil conservation district enabling legislation to assist with the administration of the provisions of the state soil conservation districts law. The official title may vary from the above as new or amended state laws are made.

Stocking - The degree to which an area is effectively covered with living trees. Fully stocked stands contain as many trees per acre as can properly use the growing space available.

Stream - A general term for a body of flowing water. In hydrology the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally, as in the term stream gaging, it is applied to the water flowing in any channel, natural or artificial.

Streambanks - The usual boundaries, not the flood boundaries, of a stream channel. Right and left banks are named facing downstream.

Strip mining - A process in which rock and top soil strata overlying ore or fuel deposits are scraped away by mechanical shovel. Also known as surface mining.

Surface water - The water on the surface of the land, representing the drainage from the land. When we speak of surface water we mean streamflow, regardless of its source. Lakes and reservoirs are viewed as streamflow in storage.

Suspended sediment - Sediment suspended in water by the upward components of turbulent currents or by colloidal suspension.

Suspended solids - Any solid substances present in water in an undissolved state, usually contributing directly to turbidity.

Swamp - An area saturated with water throughout much of the year but with the surface of the soil usually not deeply submerged, usually characterized by tree or shrub vegetation. See marsh; miscellaneous land type.

Technical assistance - Aid available for professional forestry information and advice on the treatment of trees and forest land.

Technical externalities - Changes in income of a person or firm due to efficiency of production functions resulting from improved technology from the action of a different person or firm.

Temporary pasture - A pasture designed to provide grazing for only a short period, usually consisting of annual plants.

Terrace - An embankment or combination of an embankment and channel constructed across a slope to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope. Terraces or terrace systems may be classified by their alignment, gradient, outlet, and cross section. Alignment is parallel or non-parallel. Gradient may be level, uniformly graded, or variably graded. Grade is often incorporated to permit paralleling the terraces. Outlets may be soil infiltration only, vegetated waterways, tile outlets, or combinations of these. Cross sections may be narrow base, broad base, bench, steep backslope, flat channel, or channel.

Terrestrial - Pertaining to or existing on the land.

Till - (1) Unstratified glacial drift deposited directly by the ice and consisting of clay, sand, gravel, and boulders intermingled in any proportion; (2) To plow and prepare for seeding; to seed or cultivate the soil.

Timber stand improvement (TSI) - The cultural operations of cleaning sapling stands, thinning pole and small sawtimber stands and cull tree removal for purposes of improving the existing stand of trees.

Toxic materials - Materials that through chemical or physical action, kill, injure, or impair an organism.

Turbidity - Turbidity is an expression of the optical property of a sample of water which causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. The Jackson candle turbidimeter is the standard instrument for making measurements of turbidity. Field determinations, however, are made with direct reading colorimeters calibrated for this test and the results are expressed as Jackson Turbidity Units (JTU).

Understory - That portion of the trees in a forest below the upper crown cover. Syn. underwood. Contrast with overstory.

Urban and Built-up Areas - These lands include cities, villages, other built-up areas of more than 10 acres, industrial sites, railroad yards, cemeteries, airports, golf courses, shooting ranges, institutional and public administrative sites, and similar areas. This separation will not necessarily include all land inside city and village limits and will include some land outside of such limits. Nonfarm rural residences are accounted for as other land not in farm and not included in urban.

Vacation farm - A rural area operated as a working or simulated farm with vacation living accommodations for rent.

Vegetation - Plants in general or the sum total of plant life in an area.

Vegetation type - A plant community with distinguishable characteristics.

Vegetative Index of Fields (V.I.F.) - Reflects the numerical rating value for wildlife (quail) of growing crops, grasslands, rough and odd areas. A value derived from the average numerical field value of the parameter(s) per transect mile x the H.D.I. of the parameter per transect mile.

Vegetative Index of Woods (V.I.W.) - Reflects the numerical rating value for wildlife (quail) of woodland tracts. A value derived from the average numerical value of woodland crown closure game values per transect mile x the H.D.I. of the parameter per transect mile.

Volume of growing stock - The volume in cubic feet of sound wood in the bole of growing-stock trees, from a 1-foot stump to a minimum 4.0-inch top diamter inside bark.

Volume of sawtimber - Net volume of the saw log portion of live sawtimber trees in board feet international $\frac{1}{4}$ inch rule measured between the stump and a point in the top of the stem at which utilization is limited by large branches, fork or other defects, or by a diameter inside bark of 8 inches.

Warm-season plant - A plant that completes most of its growth during the warm portion of the year, generally late spring and summer.

Water and wet areas - Water and wet areas definitions, as used by the Census, were used. These are as follows:

1. Water, more than 40 acres - Permanent lakes, reservoirs, and ponds more than 40 acres in size; streams, sloughs, estuaries, and canals more than one-eighth of a statutue mile in width. Any part of such a body of water that was included in a sample unit was identified on the soil survey map, but its area was not included in the soil survey data.

2. Water less than 40 acres - Permanent bodies of water as listed above less than 40 acres in size or streams less than one-eighth of a mile wide.

3. Intermittent water - Lakes and sloughs dry for several months of the year and not identified by soil mapping units. Conventional soil survey procedures were used in delineation of intermittent water.

Water quality standards - Minimum requirements of purity of water for various uses; for example, water for agricultural use in irrigation systems should not exceed specific levels of sodium bicarbonates, pH, total dissolved salts, etc.

Water yield - The runoff from the drainage basin, including ground water outflow that appears in the stream, plus ground water outflow that bypasses the gaging station and leaves the basin underground, and minus ground water inflow that moves into the drainage basin underground from adjacent drainage basins. Water yield is the precipitation minus the evapotranspiration.

Watershed area - All land and water within the confines of a drainage divide or a water problem area consisting in whole or in part of land needing drainage or irrigation.

Watershed planning - Formulation of a plan to use and treat water and land resources.

Wetland Types:

Type 3 - Inland Shallow Fresh Marshes—the soil is usually waterlogged during the growing season; often it is covered with as much as 6 inches or more of water. Vegetative cover may be relatively uniform throughout the entire wetland basin. Typical vegetation is smartweed, arrowhead, sedges, bulrushes, cattails, and spike-rushes.

Type 4 - Inland Deep Fresh Marshes—the soil is covered with 6 inches to 3 feet or more of water during the growing season. Typical vegetation is cattails, bulrushes, reeds, spikerushes, coontail, pondweeds, watermilfoil, and waterlilies.

Type 5 - Inland Open Fresh Water—shallow ponds, oxbow lakes, and reservoirs are included in this type. Water is usually less than 10 feet deep and is fringed by a border of emergent vegetation similar to type 4. Type 5 wetlands have more open water and sometimes deeper water than type 4; however, the vegetation on both types is similar.

Type 6 - Shrub Swamps—the soil is usually waterlogged during the growing season and is often covered with as much as 6 inches of water. Shrub swamps are located almost entirely in the flood plains of rivers and streams. The vegetation of these tracts is comprised of willows, buttonbush, swamp privet, swamp rose, and dogwoods.

Wildfire - Uncontrolled or unsuppressed fire that is highly destructive and difficult to extinguish.

Wood product industry - Establishments primarily engaged in the utilization of various wood raw materials.

Yellow boy - An iron precipitate in streams.

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